

Welcome to STN International! Enter x:X

PASSWORD:

\* \* \* \* \* Welcome to STN International \* \* \* \* \*

NEWS EXPRESS JUNE 27 08 CURRENT WINDOWS VERSION IS V8.3,  
AND CURRENT DISCOVER FILE IS DATED 23 JUNE 2008.

Enter NEWS followed by the item number or name to see news on that specific topic.

\* \* \* \* \* STN Columbus \* \* \* \* \*

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=> file registry
```

FILE 'REGISTRY' ENTERED AT 19:41:54 ON 31 JAN 2009

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Property values tagged with IC are from the ZIC/VINITI data file provided by InfoChem.

STRUCTURE FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3  
DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

New CAS Information Use Policies, enter HELP USAGETERMS for details.

TSCA INFORMATION NOW CURRENT THROUGH July 5, 2008.

Please note that search-term pricing does apply when conducting SmartSELECT searches.

REGISTRY includes numerically searchable data for experimental and predicted properties as well as tags indicating availability of experimental property data in the original document. For information on property searching in REGISTRY, refer to:

<http://www.cas.org/support/stngen/stndoc/properties.html>

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and 0.1-0.3 Mo/mac

475538 0.1-0.3/MAC  
273599 C/MAC  
145576 0.1-0.3 C/MAC  
(0.1-0.3/MAC (P) C/MAC)  
358258 1.0-1.5/MAC  
393253 MN/MAC  
102131 1.0-1.5 MN/MAC  
(1.0-1.5/MAC (P) MN/MAC)  
356971 0.8-1.2/MAC  
420616 SI/MAC  
68891 0.8-1.2 SI/MAC  
(0.8-1.2/MAC (P) SI/MAC)  
323205 1.0-1.4/MAC  
345555 CR/MAC  
32082 1.0-1.4 CR/MAC  
(1.0-1.4/MAC (P) CR/MAC)  
475538 0.1-0.3/MAC  
207475 MO/MAC  
53856 0.1-0.3 MO/MAC  
(0.1-0.3/MAC (P) MO/MAC)

L1 1415 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4 CR/MAC AND 0.1-0.3 MO/MAC

=> l1 and 0-0.30 Cu/mac

L1 IS NOT A RECOGNIZED COMMAND

The previous command name entered was not recognized by the system.  
For a list of commands available to you in the current file, enter "HELP COMMANDS" at an arrow prompt (=>).

=> s l1 and 0-0.30 Cu/mac

475715 0-0.30/MAC  
245265 CU/MAC  
60826 0-0.30 CU/MAC  
(0-0.30/MAC (P) CU/MAC)

L2 692 L1 AND 0-0.30 CU/MAC

=> file caplus, uspatfull, scisearch  
COST IN U.S. DOLLARS

SINCE FILE	TOTAL
ENTRY	SESSION

FULL ESTIMATED COST 33.54 33.76

FILE 'CAPLUS' ENTERED AT 19:43:41 ON 31 JAN 2009  
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FILE 'USPATFULL' ENTERED AT 19:43:41 ON 31 JAN 2009  
CA INDEXING COPYRIGHT (C) 2009 AMERICAN CHEMICAL SOCIETY (ACS)

FILE 'SCISEARCH' ENTERED AT 19:43:41 ON 31 JAN 2009  
Copyright (c) 2009 The Thomson Corporation

=> s l1 and steel  
'MAC' IS NOT A VALID FIELD CODE  
L3 1668 L1 AND STEEL

=> s l2 and steel  
'MAC' IS NOT A VALID FIELD CODE  
L4 816 L2 AND STEEL

=> s l4 and patent/dt  
L5 718 L4 AND PATENT/DT

=> d 15 718

L5 ANSWER 718 OF 718 USPATFULL on STN  
AN 80:44867 USPATFULL  
TI Method of manufacturing rolled wire rod  
IN Theis, Klaus, Hamburg, Germany, Federal Republic of  
Forster, Eckehard, Seevetal, Germany, Federal Republic of  
Becher, Wolfram, Neumunster, Germany, Federal Republic of  
Topfer, deceased, Hans-Jorg, late of Buxtehude, Germany, Federal  
Republic of by Marion o pfer, heiress  
PA Hamburger Stahlwerke GmbH, Hamburg, Germany, Federal Republic of  
(non-U.S. corporation)  
PI US 4222257 19800916  
AI US 1977-848911 19771107 (5)  
PRAI DE 1977-2717780 19770421  
DT Utility  
FS Granted  
LN.CNT 349  
INCL INCLM: 072/201.000  
INCLS: 072/700.000; 148/012.000B  
NCL NCLM: 072/201.000  
NCLS: 072/700.000; 148/596.000; 148/664.000  
IC [1]  
ICM B21B045-02  
ICS C21D008-06; C21D009-52  
IPCI B21B0045-02 [ICM,1]; C21D0008-06 [ICS,1]; C21D0009-52 [ICS,1]  
IPCR B21B0039-20 [I,C\*]; B21B0039-28 [I,A]; B21B0045-02 [I,C\*];  
B21B0045-02 [I,A]; C21D0008-06 [I,C\*]; C21D0008-06 [I,A];  
C22C0038-02 [I,C\*]; C22C0038-02 [I,A]; C22C0038-04 [I,C\*];  
C22C0038-04 [I,A]  
EXF 072/201; 072/364; 072/365; 072/700; 148/12B; 148/12.4; 148/156  
CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> d 15 718 abs

L5 ANSWER 718 OF 718 USPATFULL on STN  
AB A method and apparatus of manufacturing wire rod having a content of

silicon and manganese greater than 1.5% is described, wherein the average final rolling temperature in processing the rod is from 870° C. to 970° C. and the rod is cooled in an extended position. The composition of steels utilized in the method is also described.

CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> file registry  
COST IN U.S. DOLLARS

SINCE FILE	TOTAL
ENTRY	SESSION
57.80	91.56

FULL ESTIMATED COST  
  
FILE 'REGISTRY' ENTERED AT 19:45:47 ON 31 JAN 2009  
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DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

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TSCA INFORMATION NOW CURRENT THROUGH July 5, 2008.

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REGISTRY includes numerically searchable data for experimental and predicted properties as well as tags indicating availability of experimental property data in the original document. For information on property searching in REGISTRY, refer to:

<http://www.cas.org/support/stngen/stndoc/properties.html>

=> d 12 abs  
'ABS' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual fields or predefined formats. The predefined substance formats are: (RN = CAS Registry Number)

- REG - RN
- SAM - Index Name, MF, and structure - no RN
- FIDE - All substance data, except sequence data
- IDE - FIDE, but only 50 names
- SQIDE - IDE, plus sequence data
- SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used
- SQD - Protein sequence data, includes RN
- SQD3 - Same as SQD, but 3-letter amino acid codes are used
- SQN - Protein sequence name information, includes RN

- EPROP - Table of experimental properties
- PPROP - Table of predicted properties
- PROP - EPROP, ETAG, PPROP and SPEC

Any CA File format may be combined with any substance format to obtain CA references citing the substance. The substance formats must be cited first. The CA File predefined formats are:

ABS -- Abstract  
APPS -- Application and Priority Information  
BIB -- CA Accession Number, plus Bibliographic Data  
CAN -- CA Accession Number  
CBIB -- CA Accession Number, plus Bibliographic Data (compressed)  
IND -- Index Data  
IPC -- International Patent Classification  
PATS -- PI, SO  
STD -- BIB, IPC, and NCL  
  
IABS -- ABS, indented, with text labels  
IBIB -- BIB, indented, with text labels  
ISTD -- STD format, indented  
  
OBIB ----- AN, plus Bibliographic Data (original)  
OIBIB ----- OBIB, indented with text labels  
  
SBIB ----- BIB, no citations  
SIBIB ----- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when it is available.

The MAX format is the same as ALL.

The IALL format is the same as ALL with BIB ABS and IND indented, with text labels.

For additional information, please consult the following help messages:

HELP DFIELDS -- To see a complete list of individual display fields.  
HELP FORMATS -- To see detailed descriptions of the predefined formats.  
ENTER DISPLAY FORMAT (IDE):sbib  
'SBIB' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual fields or predefined formats. The predefined substance formats are: (RN = CAS Registry Number)

REG - RN  
SAM - Index Name, MF, and structure - no RN  
FIDE - All substance data, except sequence data  
IDE - FIDE, but only 50 names  
SQIDE - IDE, plus sequence data  
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used  
SQD - Protein sequence data, includes RN  
SQD3 - Same as SQD, but 3-letter amino acid codes are used  
SQN - Protein sequence name information, includes RN  
  
EPROP - Table of experimental properties  
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STD -- BIB, IPC, and NCL  
  
IABS -- ABS, indented, with text labels  
IBIB -- BIB, indented, with text labels  
ISTD -- STD format, indented

OBIB ----- AN, plus Bibliographic Data (original)  
OIBIB ----- OBIB, indented with text labels

SBIB ----- BIB, no citations  
SIBIB ----- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when it is available.

The MAX format is the same as ALL.

The IALL format is the same as ALL with BIB ABS and IND indented, with text labels.

For additional information, please consult the following help messages:

HELP DFIELDS -- To see a complete list of individual display fields.  
HELP FORMATS -- To see detailed descriptions of the predefined formats.  
ENTER DISPLAY FORMAT (IDE):cancel  
'CANCEL' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual fields or predefined formats. The predefined substance formats are: (RN = CAS Registry Number)

REG - RN  
SAM - Index Name, MF, and structure - no RN  
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IDE - FIDE, but only 50 names  
SQIDE - IDE, plus sequence data  
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used  
SQD - Protein sequence data, includes RN  
SQD3 - Same as SQD, but 3-letter amino acid codes are used  
SQN - Protein sequence name information, includes RN

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BIB -- CA Accession Number, plus Bibliographic Data  
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IABS -- ABS, indented, with text labels  
IBIB -- BIB, indented, with text labels  
ISTD -- STD format, indented

OBIB ----- AN, plus Bibliographic Data (original)  
OIBIB ----- OBIB, indented with text labels

SBIB ----- BIB, no citations  
SIBIB ----- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when it is available.

The MAX format is the same as ALL.

The IALL format is the same as ALL with BIB ABS and IND indented, with text labels.

For additional information, please consult the following help messages:

HELP DFIELDS -- To see a complete list of individual display fields.  
HELP FORMATS -- To see detailed descriptions of the predefined formats.  
ENTER DISPLAY FORMAT (IDE):exit  
'EXIT' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual fields or predefined formats. The predefined substance formats are: (RN = CAS Registry Number)

REG - RN  
SAM - Index Name, MF, and structure - no RN  
FIDE - All substance data, except sequence data  
IDE - FIDE, but only 50 names  
SQIDE - IDE, plus sequence data  
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used  
SQD - Protein sequence data, includes RN  
SQD3 - Same as SQD, but 3-letter amino acid codes are used  
SQN - Protein sequence name information, includes RN

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PPROP - Table of predicted properties  
PROP - EPROP, ETAG, PPROP and SPEC

Any CA File format may be combined with any substance format to obtain CA references citing the substance. The substance formats must be cited first. The CA File predefined formats are:

ABS -- Abstract  
APPS -- Application and Priority Information  
BIB -- CA Accession Number, plus Bibliographic Data  
CAN -- CA Accession Number  
CBIB -- CA Accession Number, plus Bibliographic Data (compressed)  
IND -- Index Data  
IPC -- International Patent Classification  
PATS -- PI, SO

STD -- BIB, IPC, and NCL

IABS -- ABS, indented, with text labels

IBIB -- BIB, indented, with text labels

ISTD -- STD format, indented

OBIB ----- AN, plus Bibliographic Data (original)

OIBIB ----- OBIB, indented with text labels

SBIB ----- BIB, no citations

SIBIB ----- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when it is available.

The MAX format is the same as ALL.

The IALL format is the same as ALL with BIB ABS and IND indented, with text labels.

For additional information, please consult the following help messages:

HELP DFIELDS -- To see a complete list of individual display fields.

HELP FORMATS -- To see detailed descriptions of the predefined formats.

ENTER DISPLAY FORMAT (IDE):istd

'ISTD' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual fields or predefined formats. The predefined substance formats are: (RN = CAS Registry Number)

REG - RN

SAM - Index Name, MF, and structure - no RN

FIDE - All substance data, except sequence data

IDE - FIDE, but only 50 names

SQIDE - IDE, plus sequence data

SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used

SQD - Protein sequence data, includes RN

SQD3 - Same as SQD, but 3-letter amino acid codes are used

SQN - Protein sequence name information, includes RN

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PPROP - Table of predicted properties

PROP - EPROP, ETAG, PPROP and SPEC

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ABS -- Abstract

APPS -- Application and Priority Information

BIB -- CA Accession Number, plus Bibliographic Data

CAN -- CA Accession Number

CBIB -- CA Accession Number, plus Bibliographic Data (compressed)

IND -- Index Data

IPC -- International Patent Classification

PATS -- PI, SO

STD -- BIB, IPC, and NCL

IABS -- ABS, indented, with text labels

IBIB -- BIB, indented, with text labels



ISTD -- STD format, indented

OBIB ----- AN, plus Bibliographic Data (original)

OIBIB ----- OBIB, indented with text labels

SBIB ----- BIB, no citations

SIBIB ----- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when it is available.

The MAX format is the same as ALL.

The IALL format is the same as ALL with BIB ABS and IND indented, with text labels.

For additional information, please consult the following help messages:

HELP DFIELDS -- To see a complete list of individual display fields.

HELP FORMATS -- To see detailed descriptions of the predefined formats.

ENTER DISPLAY FORMAT (IDE):reg

1           RN           1093218-16-6   REGISTRY

=> file registry

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
FULL ESTIMATED COST	1.21	92.77

FILE 'REGISTRY' ENTERED AT 19:46:44 ON 31 JAN 2009

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DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

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=> d 12 2

L2 ANSWER 2 OF 692 REGISTRY COPYRIGHT 2009 ACS on STN

RN 1093216-10-4 REGISTRY

ED Entered STN: 12 Jan 2009

CN INDEX NAME NOT YET ASSIGNED

MF C . Al . Bi . Co . Cr . Cu . Fe . Ge . Mn . Mo . Ni . P . Sb . Se . Si .  
Sn . Te . Unspecified . W

CI AYS

SR CA  
LC STN Files: CA, CAPLUS

Component	Component Percent	Component Registry Number
Fe	48 - 98	7439-89-6
Cr	0 - 15	7440-47-3
Cu	0 - 8	7440-50-8
Al	2.5 - 6	7429-90-5
Co	0 - 4	7440-48-4
Mo	0 - 4	7439-98-7
W	0 - 4	7440-33-7
Si	0 - 3.5	7440-21-3
Mn	0 - 3	7439-96-5
Ni	0 - 2	7440-02-0
Ge	0 - 0.5	7440-56-4
Sb	0 - 0.5	7440-36-0
Sn	0 - 0.5	7440-31-5
P	0 - 0.3	7723-14-0
Se	0 - 0.3	7782-49-2
Te	0 - 0.3	13494-80-9
Bi	0 - 0.2	7440-69-9
C	0 - 0.1	7440-44-0
Misch metal	0 - 0.1	8049-20-5

3 REFERENCES IN FILE CA (1907 TO DATE)  
3 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> file registry		
COST IN U.S. DOLLARS	SINCE FILE	TOTAL
	ENTRY	SESSION
FULL ESTIMATED COST	2.53	95.30

FILE 'REGISTRY' ENTERED AT 19:47:07 ON 31 JAN 2009  
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DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

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experimental property data in the original document. For information  
on property searching in REGISTRY, refer to:

<http://www.cas.org/support/stngen/stndoc/properties.html>

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac  
and 0-0.1 S/mac and 80-100 Fe/mac

475538 0.1-0.3/MAC  
 273599 C/MAC  
 145576 0.1-0.3 C/MAC  
     (0.1-0.3/MAC (P) C/MAC)  
 358258 1.0-1.5/MAC  
 393253 MN/MAC  
 102131 1.0-1.5 MN/MAC  
     (1.0-1.5/MAC (P) MN/MAC)  
 356971 0.8-1.2/MAC  
 420616 SI/MAC  
 68891 0.8-1.2 SI/MAC  
     (0.8-1.2/MAC (P) SI/MAC)  
 323205 1.0-1.4/MAC  
 345555 CR/MAC  
 32082 1.0-1.4 CR/MAC  
     (1.0-1.4/MAC (P) CR/MAC)  
 475538 0.1-0.3/MAC  
 207475 MO/MAC  
 53856 0.1-0.3 MO/MAC  
     (0.1-0.3/MAC (P) MO/MAC)  
 475715 0-0.3/MAC  
 245265 CU/MAC  
 60826 0-0.3 CU/MAC  
     (0-0.3/MAC (P) CU/MAC)  
 336565 0-0.1/MAC  
 20543 BI/MAC  
 3203 0-0.1 BI/MAC  
     (0-0.1/MAC (P) BI/MAC)  
 434955 0-0.2/MAC  
 25740 PB/MAC  
 6327 0-0.2 PB/MAC  
     (0-0.2/MAC (P) PB/MAC)  
 475715 0-0.3/MAC  
 341765 NI/MAC  
 53982 0-0.3 NI/MAC  
     (0-0.3/MAC (P) NI/MAC)  
 336565 0-0.1/MAC  
 26299 S/MAC  
 17353 0-0.1 S/MAC  
     (0-0.1/MAC (P) S/MAC)  
 524182 80-100/MAC  
 558510 FE/MAC  
 272393 80-100 FE/MAC  
     (80-100/MAC (P) FE/MAC)  
 L6           19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
               CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND  
               0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 80-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
 0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac  
 and 0-0.1 S/mac and 80-95 Fe/mac

475538 0.1-0.3/MAC  
 273599 C/MAC  
 145576 0.1-0.3 C/MAC  
     (0.1-0.3/MAC (P) C/MAC)  
 358258 1.0-1.5/MAC  
 393253 MN/MAC  
 102131 1.0-1.5 MN/MAC  
     (1.0-1.5/MAC (P) MN/MAC)  
 356971 0.8-1.2/MAC  
 420616 SI/MAC  
 68891 0.8-1.2 SI/MAC

(0.8-1.2/MAC (P) SI/MAC)  
 323205 1.0-1.4/MAC  
 345555 CR/MAC  
 32082 1.0-1.4 CR/MAC  
 (1.0-1.4/MAC (P) CR/MAC)  
 475538 0.1-0.3/MAC  
 207475 MO/MAC  
 53856 0.1-0.3 MO/MAC  
 (0.1-0.3/MAC (P) MO/MAC)  
 475715 0-0.3/MAC  
 245265 CU/MAC  
 60826 0-0.3 CU/MAC  
 (0-0.3/MAC (P) CU/MAC)  
 336565 0-0.1/MAC  
 20543 BI/MAC  
 3203 0-0.1 BI/MAC  
 (0-0.1/MAC (P) BI/MAC)  
 434955 0-0.2/MAC  
 25740 PB/MAC  
 6327 0-0.2 PB/MAC  
 (0-0.2/MAC (P) PB/MAC)  
 475715 0-0.3/MAC  
 341765 NI/MAC  
 53982 0-0.3 NI/MAC  
 (0-0.3/MAC (P) NI/MAC)  
 336565 0-0.1/MAC  
 26299 S/MAC  
 17353 0-0.1 S/MAC  
 (0-0.1/MAC (P) S/MAC)  
 318951 80-95/MAC  
 558510 FE/MAC  
 147519 80-95 FE/MAC  
 (80-95/MAC (P) FE/MAC)

L7            19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
                  CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND  
                  0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 80-95 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
 0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac  
 and 0-0.1 S/mac and 70-100 Fe/mac

475538 0.1-0.3/MAC  
 273599 C/MAC  
 145576 0.1-0.3 C/MAC  
 (0.1-0.3/MAC (P) C/MAC)  
 358258 1.0-1.5/MAC  
 393253 MN/MAC  
 102131 1.0-1.5 MN/MAC  
 (1.0-1.5/MAC (P) MN/MAC)  
 356971 0.8-1.2/MAC  
 420616 SI/MAC  
 68891 0.8-1.2 SI/MAC  
 (0.8-1.2/MAC (P) SI/MAC)  
 323205 1.0-1.4/MAC  
 345555 CR/MAC  
 32082 1.0-1.4 CR/MAC  
 (1.0-1.4/MAC (P) CR/MAC)  
 475538 0.1-0.3/MAC  
 207475 MO/MAC  
 53856 0.1-0.3 MO/MAC  
 (0.1-0.3/MAC (P) MO/MAC)  
 475715 0-0.3/MAC  
 245265 CU/MAC

60826 0-0.3 CU/MAC  
       (0-0.3/MAC (P) CU/MAC)  
 336565 0-0.1/MAC  
 20543 BI/MAC  
 3203 0-0.1 BI/MAC  
       (0-0.1/MAC (P) BI/MAC)  
 434955 0-0.2/MAC  
 25740 PB/MAC  
 6327 0-0.2 PB/MAC  
       (0-0.2/MAC (P) PB/MAC)  
 475715 0-0.3/MAC  
 341765 NI/MAC  
 53982 0-0.3 NI/MAC  
       (0-0.3/MAC (P) NI/MAC)  
 336565 0-0.1/MAC  
 26299 S/MAC  
 17353 0-0.1 S/MAC  
       (0-0.1/MAC (P) S/MAC)  
 639931 70-100/MAC  
 558510 FE/MAC  
 328593 70-100 FE/MAC  
       (70-100/MAC (P) FE/MAC)

L8           19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
               CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND  
               0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
 0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac  
 and 70-100 Fe/mac

475538 0.1-0.3/MAC  
 273599 C/MAC  
 145576 0.1-0.3 C/MAC  
       (0.1-0.3/MAC (P) C/MAC)  
 358258 1.0-1.5/MAC  
 393253 MN/MAC  
 102131 1.0-1.5 MN/MAC  
       (1.0-1.5/MAC (P) MN/MAC)  
 356971 0.8-1.2/MAC  
 420616 SI/MAC  
 68891 0.8-1.2 SI/MAC  
       (0.8-1.2/MAC (P) SI/MAC)  
 323205 1.0-1.4/MAC  
 345555 CR/MAC  
 32082 1.0-1.4 CR/MAC  
       (1.0-1.4/MAC (P) CR/MAC)  
 475538 0.1-0.3/MAC  
 207475 MO/MAC  
 53856 0.1-0.3 MO/MAC  
       (0.1-0.3/MAC (P) MO/MAC)  
 475715 0-0.3/MAC  
 245265 CU/MAC  
 60826 0-0.3 CU/MAC  
       (0-0.3/MAC (P) CU/MAC)  
 336565 0-0.1/MAC  
 20543 BI/MAC  
 3203 0-0.1 BI/MAC  
       (0-0.1/MAC (P) BI/MAC)  
 434955 0-0.2/MAC  
 25740 PB/MAC  
 6327 0-0.2 PB/MAC  
       (0-0.2/MAC (P) PB/MAC)  
 475715 0-0.3/MAC

341765 NI/MAC  
53982 0-0.3 NI/MAC  
(0-0.3/MAC (P) NI/MAC)  
639931 70-100/MAC  
558510 FE/MAC  
328593 70-100 FE/MAC  
(70-100/MAC (P) FE/MAC)

L9 23 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND  
0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 70-100 Fe/mac

475538 0.1-0.3/MAC  
273599 C/MAC  
145576 0.1-0.3 C/MAC  
(0.1-0.3/MAC (P) C/MAC)  
358258 1.0-1.5/MAC  
393253 MN/MAC  
102131 1.0-1.5 MN/MAC  
(1.0-1.5/MAC (P) MN/MAC)  
356971 0.8-1.2/MAC  
420616 SI/MAC  
68891 0.8-1.2 SI/MAC  
(0.8-1.2/MAC (P) SI/MAC)  
323205 1.0-1.4/MAC  
345555 CR/MAC  
32082 1.0-1.4 CR/MAC  
(1.0-1.4/MAC (P) CR/MAC)  
475538 0.1-0.3/MAC  
207475 MO/MAC  
53856 0.1-0.3 MO/MAC  
(0.1-0.3/MAC (P) MO/MAC)  
475715 0-0.3/MAC  
245265 CU/MAC  
60826 0-0.3 CU/MAC  
(0-0.3/MAC (P) CU/MAC)  
336565 0-0.1/MAC  
20543 BI/MAC  
3203 0-0.1 BI/MAC  
(0-0.1/MAC (P) BI/MAC)  
434955 0-0.2/MAC  
25740 PB/MAC  
6327 0-0.2 PB/MAC  
(0-0.2/MAC (P) PB/MAC)  
639931 70-100/MAC  
558510 FE/MAC  
328593 70-100 FE/MAC  
(70-100/MAC (P) FE/MAC)

L10 24 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND  
0-0.2 PB/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 70-100 Fe/mac

475538 0.1-0.3/MAC  
273599 C/MAC  
145576 0.1-0.3 C/MAC  
(0.1-0.3/MAC (P) C/MAC)  
358258 1.0-1.5/MAC  
393253 MN/MAC  
102131 1.0-1.5 MN/MAC

```

(1.0-1.5/MAC (P) MN/MAC)
356971 0.8-1.2/MAC
420616 SI/MAC
68891 0.8-1.2 SI/MAC
(0.8-1.2/MAC (P) SI/MAC)
323205 1.0-1.4/MAC
345555 CR/MAC
32082 1.0-1.4 CR/MAC
(1.0-1.4/MAC (P) CR/MAC)
475538 0.1-0.3/MAC
207475 MO/MAC
53856 0.1-0.3 MO/MAC
(0.1-0.3/MAC (P) MO/MAC)
475715 0-0.3/MAC
245265 CU/MAC
60826 0-0.3 CU/MAC
(0-0.3/MAC (P) CU/MAC)
336565 0-0.1/MAC
20543 BI/MAC
3203 0-0.1 BI/MAC
(0-0.1/MAC (P) BI/MAC)
639931 70-100/MAC
558510 FE/MAC
328593 70-100 FE/MAC
(70-100/MAC (P) FE/MAC)
L11      35 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
          CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
          70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 70-100 Fe/mac
475538 0.1-0.3/MAC
273599 C/MAC
145576 0.1-0.3 C/MAC
(0.1-0.3/MAC (P) C/MAC)
358258 1.0-1.5/MAC
393253 MN/MAC
102131 1.0-1.5 MN/MAC
(1.0-1.5/MAC (P) MN/MAC)
356971 0.8-1.2/MAC
420616 SI/MAC
68891 0.8-1.2 SI/MAC
(0.8-1.2/MAC (P) SI/MAC)
323205 1.0-1.4/MAC
345555 CR/MAC
32082 1.0-1.4 CR/MAC
(1.0-1.4/MAC (P) CR/MAC)
475538 0.1-0.3/MAC
207475 MO/MAC
53856 0.1-0.3 MO/MAC
(0.1-0.3/MAC (P) MO/MAC)
475715 0-0.3/MAC
245265 CU/MAC
60826 0-0.3 CU/MAC
(0-0.3/MAC (P) CU/MAC)
639931 70-100/MAC
558510 FE/MAC
328593 70-100 FE/MAC
(70-100/MAC (P) FE/MAC)
L12      688 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
          CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 70-100 FE/MAC

```

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and 0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 70-100 Fe/mac

475538 0.1-0.3/MAC  
273599 C/MAC  
145576 0.1-0.3 C/MAC  
(0.1-0.3/MAC (P) C/MAC)  
358258 1.0-1.5/MAC  
393253 MN/MAC  
102131 1.0-1.5 MN/MAC  
(1.0-1.5/MAC (P) MN/MAC)  
356971 0.8-1.2/MAC  
420616 SI/MAC  
68891 0.8-1.2 SI/MAC  
(0.8-1.2/MAC (P) SI/MAC)  
323205 1.0-1.4/MAC  
345555 CR/MAC  
32082 1.0-1.4 CR/MAC  
(1.0-1.4/MAC (P) CR/MAC)  
475538 0.1-0.3/MAC  
207475 MO/MAC  
53856 0.1-0.3 MO/MAC  
(0.1-0.3/MAC (P) MO/MAC)  
475715 0-0.3/MAC  
245265 CU/MAC  
60826 0-0.3 CU/MAC  
(0-0.3/MAC (P) CU/MAC)  
336565 0-0.1/MAC  
20543 BI/MAC  
3203 0-0.1 BI/MAC  
(0-0.1/MAC (P) BI/MAC)  
639931 70-100/MAC  
558510 FE/MAC  
328593 70-100 FE/MAC  
(70-100/MAC (P) FE/MAC)

L13 35 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4 CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND 70-100 FE/MAC

=> file caplus, uspatfull, scisearch  
COST IN U.S. DOLLARS

SINCE FILE	TOTAL
ENTRY	SESSION
404.61	499.91

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=> s l13  
'MAC' IS NOT A VALID FIELD CODE  
L14 43 L13

=> d l14 all

L14 ANSWER 1 OF 43 CAPLUS COPYRIGHT 2009 ACS on STN  
AN 2009:27896 CAPLUS



DN 150:81420  
 ED Entered STN: 09 Jan 2009  
 TI Method for manufacture of nondirectional electromagnetic steel sheets for rotors  
 IN Tanaka, Ichiro; Yashiki, Hiroyoshi; Takamaru, Hiroki; Fujita, Kaoru  
 PA Sumitomo Metal Industries Ltd., Japan  
 SO Jpn. Kokai Tokkyo Koho, 19pp.  
 CODEN: JKXXAF  
 DT Patent  
 LA Japanese  
 CC 55-11 (Ferrous Metals and Alloys)  
 FAN.CNT 1

	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI	JP 2009001887	A	20090108	JP 2007-165962	20070625
PRAI	JP 2007-165962		20070625		

CLASS

PATENT NO.	CLASS	PATENT FAMILY CLASSIFICATION CODES
JP 2009001887	IPCI	C21D0008-12 [I,A]; B21B0003-02 [I,A]; H01F0001-16 [I,A]; H01F0001-12 [I,C*]; H01F0041-02 [I,A]; C22C0038-00 [N,A]; C22C0038-14 [N,A]; C22C0038-60 [N,A]
	FTERM	4K033/AA01; 4K033/CA01; 4K033/CA02; 4K033/CA03; 4K033/CA04; 4K033/CA05; 4K033/CA06; 4K033/CA07; 4K033/CA08; 4K033/CA09; 4K033/CA10; 4K033/EA02; 4K033/FA01; 4K033/FA03; 4K033/FA10; 4K033/FA12; 4K033/GA00; 4K033/HA01; 4K033/HA03; 4K033/JA01; 4K033/KA00; 5E041/AA02; 5E041/CA04; 5E041/HB11; 5E041/NN01; 5E062/AA06; 5E062/AC15

AB Slabs or ingots of steels consisting of C  $\leq$  0.06, Si  $\leq$  3.5, Mn 0.05-3.0, Al  $>$  2.5 and  $\leq$  6.0, P  $\leq$  0.30, S  $\leq$  0.04, N  $\leq$  0.02, Nb  $>$  0.02 weight%, and balance Fe and satisfying  $0 < \text{Nb}/93 + \text{Zr}/91 + \text{Ti}/48 + \text{V}/51 - (\text{C}/12 + \text{N}/14) < 5 + 10^{-3}$  (the element symbols indicate their weight% contents) are hot rolled, cold rolled, at least once with in-between process annealing, into sheets of thickness 0.15-0.80 mm and tensile strength  $\geq$  850 MPa, and then soaked at  $\leq$  820° to give the title sheets. The steels may also contain Cu 0.01-8.0, Ni 0.01-2.0, Cr 0.01-15.0, Mo 0.005-4.0, Co 0.01-4.0, W 0.01-4.0, Sn  $\leq$  0.5, Sb  $\leq$  0.5, Se  $\leq$  0.3, Bi  $\leq$  0.2, Ge  $\leq$  0.5, Te  $\leq$  0.3, B  $\leq$  0.01, Ca  $\leq$  0.03, Mg  $\leq$  0.02, and/or rare earth metals  $\leq$  0.1 weight%. Rotors with decreased weight can be prepared from the sheets.

ST nondirectional electromagnetic steel sheet rolling rotor

IT Rolling (metals)

(hot; manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT Cold rolling

(manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT Annealing

(process; manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT Electric motors

(rotors; manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT Heat treatment

(soaking; manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT	1093215-97-4	1093215-98-5	1093215-99-6	1093216-01-3	1093216-02-4
	1093216-04-6	1093216-05-7	1093216-06-8	1093216-07-9	
	1093216-10-4				

RL: PEP (Physical, engineering or chemical process); TEM (Technical or

engineered material use); PROC (Process); USES (Uses)

(manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

IT 7439-95-4, Magnesium, uses 7440-42-8, Boron, uses 7440-70-2, Calcium, uses

RL: MOA (Modifier or additive use); USES (Uses)

(microalloying element; manufacture of nondirectional electromagnetic steel sheets for rotors by hot and cold rolling, process annealing, and soaking)

=> d 114 pi 1

L14	ANSWER 1 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2009001887	A	20090108	JP 2007-165962	20070625

=> d 114 pi 1-43

L14	ANSWER 1 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2009001887	A	20090108	JP 2007-165962	20070625

L14	ANSWER 2 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2009001864	A	20090108	JP 2007-163851	20070621

L14	ANSWER 3 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008308727	A	20081225	JP 2007-157349	20070614

L14	ANSWER 4 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008308704	A	20081225	JP 2007-154899	20070612

L14	ANSWER 5 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008149340	A	20080703	JP 2006-338791	20061215

L14	ANSWER 6 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008013788	A	20080124	JP 2006-183512	20060703

L14	ANSWER 7 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2007031787	A	20070208	JP 2005-217453	20050727

L14	ANSWER 8 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	WO 2007007423	A1	20070118	WO 2005-JP22368	20051206

W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD,

GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ,  
 LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ,  
 NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG,  
 SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,  
 YU, ZA, ZM, ZW  
 RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,  
 IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF, BJ,  
 CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG, BW, GH,  
 GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY,  
 KG, KZ, MD, RU, TJ, TM

JP 2007016278	A	20070125	JP 2005-198794	20050707
JP 2007023351	A	20070201	JP 2005-208597	20050719
JP 2007031755	A	20070208	JP 2005-214625	20050725
CN 101218362	A	20080709	CN 2005-80050983	20080104
KR 2008027913	A	20080328	KR 2008-702741	20080201
IN 2008CN00647	A	20081128	IN 2008-CN647	20080207

L14	ANSWER 9 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2006348321	A	20061228	JP 2005-173112	20050614

L14	ANSWER 10 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2006299296	A	20061102	JP 2005-118366	20050415

L14	ANSWER 11 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2006249457	A	20060921	JP 2005-64316	20050308

L14	ANSWER 12 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2006206967	A	20060810	JP 2005-21019	20050128

L14	ANSWER 13 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2006037177	A	20060209	JP 2004-220223	20040728

L14	ANSWER 14 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	FR 2868083	A1	20050930	FR 2004-3038	20040324
	FR 2868083	B1	20060721		
	AU 2005232002	A1	20051020	AU 2005-232002	20050321
	CA 2559562	A1	20051020	CA 2005-2559562	20050321
	WO 2005098070	A2	20051020	WO 2005-FR684	20050321
	WO 2005098070	A3	20061005		

W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,  
 CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD,  
 GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
 LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI,  
 NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM,  
 SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW  
 RW: BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM,  
 AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK,  
 EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT,  
 RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML,  
 MR, NE, SN, TD, TG

EP 1727919	A2	20061206	EP 2005-742733	20050321
R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LI, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR, AL, BA, HR, LV, MK, YU				
CN 1950533	A	20070418	CN 2005-80014026	20050321
BR 2005008776	A	20070904	BR 2005-8776	20050321
JP 2007530780	T	20071101	JP 2007-504447	20050321
US 20070193658	A1	20070823	US 2006-593463	20060919
MX 2006010816	A	20061120	MX 2006-10816	20060921
IN 2006CN03491	A	20070615	IN 2006-CN3491	20060922
KR 2007021185	A	20070222	KR 2006-722040	20061024

L14	ANSWER 15 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2005220423	A	20050818	JP 2004-30993	20040206
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L14	ANSWER 16 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2005059096	A	20050310	JP 2004-199624	20040706
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L14	ANSWER 17 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2004292929	A	20041021	JP 2003-89959	20030328
	JP 3912308	B2	20070509		

L14	ANSWER 18 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2004025205	A	20040129	JP 2002-182228	20020621
	JP 3789856	B2	20060628		

L14	ANSWER 19 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	EP 1335035	A1	20030813	EP 2003-250686	20030203
	EP 1335035	B1	20050420		
	R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK				
	JP 2003226933	A	20030815	JP 2002-26368	20020204
	JP 3758581	B2	20060322		
	TW 228149	B	20050221	TW 2003-92102006	20030129
	CN 1436875	A	20030820	CN 2003-103453	20030130
	CN 1210432	C	20050713		
	US 20030152476	A1	20030814	US 2003-357419	20030204

L14	ANSWER 20 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2003147481	A	20030521	JP 2001-349097	20011114
	JP 3851146	B2	20061129		

L14	ANSWER 21 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2003147479	A	20030521	JP 2001-349095	20011114
	JP 3901994	B2	20070404		

L14	ANSWER 22 OF 43	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE

PI	JP 2003147435 JP 3747365	A B2	20030521 20060222	JP 2001-349098	20011114
L14	ANSWER 23 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147482 JP 3851147	A B2	20030521 20061129	JP 2001-349100	20011114
L14	ANSWER 24 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147436 JP 3750737	A B2	20030521 20060301	JP 2001-349099	20011114
L14	ANSWER 25 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	FR 2830261 JP 2003183770 JP 3468239 CN 1410581 CN 1180113 US 20030084965 US 6838048	A1 A B2 A C A1 B2	20030404 20030703 20031117 20030416 20041215 20030508 20050104	FR 2002-11966 JP 2002-112457  CN 2002-144079  US 2002-259744	20020927 20020415  20020930  20020930
L14	ANSWER 26 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003073735 JP 4213370	A B2	20030312 20090121	JP 2001-258353	20010828
L14	ANSWER 27 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2001234279	A	20010828	JP 2000-44821	20000222
L14	ANSWER 28 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2001192765 JP 3253293 EP 1167561 R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO	A B2 A2	20010717 20020204 20020102	JP 2000-193780  EP 2000-125344	20000628  20001130
L14	ANSWER 29 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2001152278	A	20010605	JP 1999-331045	19991122
L14	ANSWER 30 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2001131684	A	20010515	JP 1999-314366	19991104
L14	ANSWER 31 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2000273574	A	20001003	JP 1999-81629	19990325

L14	ANSWER 32 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2000219936	A	20000808	JP 1999-23459	19990201
L14	ANSWER 33 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	WO 2000044953 W: CA, CN, KR, US RW: AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE	A1	20000803	WO 2000-JP369	20000125
	CA 2323952	A1	20000803	CA 2000-2323952	20000125
	EP 1069198	A1	20010117	EP 2000-900930	20000125
	R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, FI				
	CN 1113973	C	20030709	CN 2000-800083	20000125
	JP 2000282172	A	20001010	JP 2000-18101	20000127
	JP 3680674	B2	20050810		
	JP 2001214241	A	20010807	JP 2000-204882	20000706
	JP 3680708	B2	20050810		
	US 6475305	B1	20021105	US 2000-669552	20000926
L14	ANSWER 34 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2000026933	A	20000125	JP 1998-192878	19980708
	JP 3893756	B2	20070314		
L14	ANSWER 35 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 11001743	A	19990106	JP 1998-52103	19980304
	JP 3489656	B2	20040126		
L14	ANSWER 36 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 10152754	A	19980609	JP 1997-249242	19970912
	JP 3724142	B2	20051207		
L14	ANSWER 37 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 09025541	A	19970128	JP 1995-175318	19950712
L14	ANSWER 38 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 07150293	A	19950613	JP 1993-296667	19931126
L14	ANSWER 39 OF 43 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 06248341	A	19940906	JP 1993-33687	19930223
L14	ANSWER 40 OF 43	USPATFULL	on STN		
PI	US 20070193658	A1	20070823		
L14	ANSWER 41 OF 43	USPATFULL	on STN		
PI	US 20030152476	A1	20030814		

L14 ANSWER 42 OF 43 USPATFULL on STN  
PI US 20030084965 A1 20030508  
US 6838048 B2 20050104

L14 ANSWER 43 OF 43 USPATFULL on STN  
PI US 6475305 B1 20021105

=> file registry

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
FULL ESTIMATED COST	63.69	563.60
DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)	SINCE FILE ENTRY	TOTAL SESSION
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=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and  
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 70-100 Fe/mac

475538 0.1-0.3/MAC  
273599 C/MAC  
145576 0.1-0.3 C/MAC  
(0.1-0.3/MAC (P) C/MAC)  
358258 1.0-1.5/MAC  
393253 MN/MAC  
102131 1.0-1.5 MN/MAC  
(1.0-1.5/MAC (P) MN/MAC)  
356971 0.8-1.2/MAC  
420616 SI/MAC  
68891 0.8-1.2 SI/MAC  
(0.8-1.2/MAC (P) SI/MAC)  
323205 1.0-1.4/MAC  
345555 CR/MAC  
32082 1.0-1.4 CR/MAC  
(1.0-1.4/MAC (P) CR/MAC)  
475538 0.1-0.3/MAC  
207475 MO/MAC

53856 0.1-0.3 MO/MAC  
       (0.1-0.3/MAC (P) MO/MAC)  
 475715 0-0.3/MAC  
 245265 CU/MAC  
       60826 0-0.3 CU/MAC  
           (0-0.3/MAC (P) CU/MAC)  
 639931 70-100/MAC  
 558510 FE/MAC  
 328593 70-100 FE/MAC  
       (70-100/MAC (P) FE/MAC)  
 L15       688 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4  
           CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 70-100 FE/MAC

=> file caplus, uspatfull, scisearch  
 COST IN U.S. DOLLARS

SINCE FILE	TOTAL
ENTRY	SESSION
37.93	601.53

FULL ESTIMATED COST

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)

SINCE FILE	TOTAL
ENTRY	SESSION
0.00	-0.82

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FILE 'SCISEARCH' ENTERED AT 19:52:46 ON 31 JAN 2009  
 Copyright (c) 2009 The Thomson Corporation

=> s l15 and steel  
 'MAC' IS NOT A VALID FIELD CODE  
 L16       816 L15 AND STEEL

=> s l16 and (niobium or columbium or nb)  
 L17       523 L16 AND (NIOBIUM OR COLUMBIUM OR NB)

=> s l17 and (copper or cu)  
 L18       484 L17 AND (COPPER OR CU)

=> s steel and (carbon or c) and (manganese or mn) and (silicon or si) and (sulfur  
 or sulphur or s) and (phosphorus or p) and (nickel or ni) and (chromium or cr) and  
 (molybdenum or mo) and (copper or cu) and (aluminum or aluminium or al) and  
 (niobium or columbium or nb or cb)  
 L19       9168 STEEL AND (CARBON OR C) AND (MANGANESE OR MN) AND (SILICON OR  
           SI) AND (SULFUR OR SULPHUR OR S) AND (PHOSPHORUS OR P) AND (NICK  
           EL OR NI) AND (CHROMIUM OR CR) AND (MOLYBDENUM OR MO) AND (COPPE  
           R OR CU) AND (ALUMINUM OR ALUMINIUM OR AL) AND (NIOBIUM OR COLUM  
           BIUM OR NB OR CB)

=> s l19 and (nitrogen or n) and (bismuth or bi) and (selenium or se) and (calcium  
 or ca) and (iron or fe)  
 L20       878 L19 AND (NITROGEN OR N) AND (BISMUTH OR BI) AND (SELENIUM OR  
           SE) AND (CALCIUM OR CA) AND (IRON OR FE)

=> s l20 and (tellerium or te)  
 L21       426 L20 AND (TELLERIUM OR TE)

=> s l21 and (hardenability or jominy)



L22 30 L21 AND (HARDENABILITY OR JOMINY)

=> d 122 all

L22 ANSWER 1 OF 30 USPATFULL on STN

AN 2008:283040 USPATFULL

TI Component for Machine Structure, Method of Producing the Same and  
Material for Induction Hardening

IN Hayashi, Toru, Okayama, JAPAN

Ohmori, Yasuhiro, Okayama, JAPAN

Kurosawa, Nobutaka, Okayama, JAPAN

Matsuzaki, Akihiro, Chiba, JAPAN

Toyooka, Takaaki, Okayama, JAPAN

Yamada, Katsumi, Kanagawa, JAPAN

PA JFE STEEL CORPORATION, Chiyoda-ku, Tokyo, JAPAN (non-U.S. corporation)

PI US 20080247900 A1 20081009

AI US 2005-587731 A1 20050705 (11)

WO 2005-JP12397 20050705

20061027 PCT 371 date

PRAI WO 2005-JP10200 20040716

DT Utility

FS APPLICATION

LREP FRISHAUF, HOLTZ, GOODMAN & CHICK, PC, 220 Fifth Avenue, 16TH Floor, NEW  
YORK, NY, 10001-7708, US

CLMN Number of Claims: 38

ECL Exemplary Claim: 1

DRWN 5 Drawing Page(s)

AB There is provided a component for machine structure having a hardened  
layer through an induction hardening in at least a part thereof, and  
more improving fatigue strengths as compared with the conventional ones,  
in which the hardened layer has a hardness Hv of not less than 750 and  
an average grain size of prior austenite grains is not more than 7  $\mu\text{m}$   
over a full thickness of the hardened layer.

SUMM TECHNICAL FIELD

This invention relates to a component for machine structure provided in  
at least a part thereof with a hardened layer through an induction  
hardening. As the component for machine structure may be mentioned a  
drive shaft for an automobile, an input shaft, an output shaft, a  
crankshaft, inner and outer wheels of a constant velocity joint, a hub,  
a gear and so on.

RELATED ART

Heretofore, in the components for machine structure such as a drive  
shaft for an automobile, a constant velocity joint and the like, it is  
usual to ensure fatigue strengths as a characteristic of the component  
for machine structure such as torsional fatigue strength, bending  
fatigue strength, rolling fatigue strength, slip rolling fatigue  
strength and the like by working a hot rolled steel bar into a  
given shape through hot forging, cutting, cold forging and the like and  
then subjecting to induction hardening and tempering.

On the other hand, it is strongly demanded to reduce the weight of the  
component for the automobile from recent environmental problems. From  
this viewpoint, it is demanded to more improve the fatigue strengths in  
the components for the automobile.

As the means for improving the fatigue strengths as mentioned above,  
there are proposed various methods up to now.

For example, it is considered to increase the hardening depth in the induction hardening for improving the torsional fatigue strength. However, the fatigue strength is saturated at a certain depth even in the increase of the hardening depth.

Also, it is effective to improve the grain boundary strength for the improvement of the torsional fatigue strength. From this viewpoint, there is proposed a technique of refining a particle size of prior austenite by dispersing TiC (see, for example, Patent Document 1).

According to the technique disclosed in the above Patent Document 1, it is attempted to refine the particle size of prior austenite by dispersing a great amount of fine TiC in the heating of the induction hardening, so that it is required to solid-solute TiC prior to the hardening, and hence it is adopted to conduct the heating above 1100° C. at the hot rolling step. For this end, it is required to raise the heating temperature in the hot rolling, so that there is a problem that the productivity is poor.

Also, there is still a problem that the recent demand on the fatigue strengths is not sufficiently satisfied even by the technique disclosed in Patent Document 1.

Furthermore, Patent Document 2 proposes a shaft component for machine structure wherein the torsional fatigue strength is improved by restricting a ratio of a depth of the hardened layer CD to a radius of the induction hardened shaft component R ( $CD/R$ ) to 0.3-0.7 and further controlling a value A defined with  $CD/R$ , austenite particle size  $\gamma_f$  from a surface to 1 mm after the induction hardening, average Vickers hardness Hv to  $(CD/R)=0.1$  as induction-hardened and average Vickers hardness in a shaft central portion after the induction hardening to a predetermined range.

However, there is a limit in the improvement of the fatigue properties even in the control of  $CD/R$ , so that the recent demand on the torsional fatigue strength could not be yet satisfied.

Patent Document 1: JP-A-2000-154819 (claims, paragraph [0008])

Patent Document 2: JP-A-H08-53714 (claims)

## DISCLOSURE OF THE INVENTION

### Problems to be Solved by the Invention

It is an object of the invention to provide a component for machine structure capable of more improving the fatigue strength as compared with the conventional ones after the induction hardening and a method of producing the same as well as a material for the induction hardening.

### Means for Solving Problems

The inventors have made various studies in order to effectively improve the fatigue strengths of steel materials through the induction hardening. Particularly, the inventors have noticed the torsional fatigue strength as a typical example of the fatigue strengths and made detail examinations thereon, and obtained the following discoveries.

- (i) Although the fatigue strength is improved by increasing a transgranular strength of a hardened layer through the induction hardening or a hardness thereof, when the hardness is increased to not less than 750 as a Vickers hardness Hv, the fracture migrates from the transgranular fracture to a fracture at a grain boundary of prior austenite, so that the fatigue strength is not improved even if the hardness is increased over the above value.

- (ii) The strength of the prior austenite grain boundary can be improved by refining the grain size of the prior austenite in the hardened layer through the induction hardening, and hence the increase of the fatigue strength can be attained in accordance with the increase of the hardness by making the average grain size of the prior austenite to not more than 7  $\mu\text{m}$  even if the hardness Hv is not less than 750.
- (iii) In order than the hardness Hv of the hardened layer is not less than 750, it is effective to increase contents of one or more of C, Si and P in the starting material, while in order to refine the grain size of the prior austenite in the hardened layer through the induction hardening, it is effective that Mo, B and Ti are included in the starting material and the microstructure prior to the induction hardening is made a fine bainite or martensite introduced with a worked strain through cold working and further that a rapid heating is conducted in the induction hardening and a heating temperature is made low and further a residence time above 800° C. is made short.
- (iv) Although the tempering is usually carried out as another means for increasing the strength after the induction hardening, it is possible to increase the transgranular strength by omitting this means.

The invention is based on the above knowledge.

That is, the thrust and construction of the invention are as follows.

1. A component for machine structure characterized by comprising a hardened layer through an induction hardening in at least a part thereof, in which the hardened layer has a hardness Hv of not less than 750 and an average grain size of prior austenite grains is not more than 7  $\mu\text{m}$  over a full thickness of the hardened layer.

2. A component for machine structure according to the item 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3):

$$C > 0.7 \text{ mass \%} \quad (1)$$

$$\text{Si} > 1.1 \text{ mass \%} \quad (2)$$

$$P > 0.02 \text{ mass \%} \quad (3)$$

3. A component for machine structure according to item 2, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

4. A component for machine structure according to item 2 or 3, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

5. A component for machine structure according to any one of items 2 to 4, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more

than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

6. A component for machine structure according to item 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass % and the remainder being Fe and inevitable impurities in which the hardened layer is not subjected to a tempering.

7. A component for machine structure according to item 6, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

8. A component for machine structure according to item 6 or 7, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

9. A component for machine structure according to any one of items 6 to 8, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

10. A component for machine structure according to any one of items 2 to 9, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}$ .sup.3 and an average particle size of the Mo-based precipitate is not more than 20 nm.

11. A method of producing a component for machine structure by subjecting at least a part of a starting material having a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3):

C>0.7 mass % (1)

Si>1.1 mass % (2)

P>0.02 mass % (3)

to an induction hardening at least once, characterized in that either or both of bainite structure and martensite structure in steel microstructure of the starting material prior to the induction hardening is adjusted to not less than 10 volume %, and a ultimate temperature of the induction hardening is not higher than 1000° C.

12. A method of producing a component for machine structure according to item 11, wherein a content of Al in the chemical composition

is Al: 0.005-0.25 mass %.

13. A method of producing a component for machine structure according to item 11 or 12, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

14. A method of producing a component for machine structure according to any one of items 11 to 13, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

15. A material for induction hardening used for the formation of a component for machine structure having in at least a part of its surface a hardened layer with an average grain size of prior austenite of not more than 7  $\mu\text{m}$  through an induction hardening, characterized by having a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3):

$$\text{C} > 0.7 \text{ mass \%} \quad (1)$$

$$\text{Si} > 1.1 \text{ mass \%} \quad (2)$$

$$\text{P} > 0.02 \text{ mass \%} \quad (3)$$

and having a steel microstructure in which either or both of bainite structure and martensite structure is not less than 10 volume %.

16. A material for induction hardening according to item 15, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

17. A material for induction hardening according to item 15 or 16, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

18. A material for induction hardening according to any one of items 15 to 17, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

19. A material for induction hardening according to any one of items 15 to 18, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^3$  and an average particle size of

the Mo-based precipitate is not more than 20 nm.

#### Effect of the Invention

According to the invention, there can be stably obtained components for machine structure having excellent fatigue properties exemplifying torsional fatigue property and rolling fatigue property, and hence there are developed considerable effects on the demands such as weight reduction of automobile parts and the like.

#### DRWD BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph showing an influence of a heating temperature in an induction hardening on a grain size of prior austenite in a hardened layer with respect to Mo-added steel and Mo-free steel;

FIG. 2 is a transmission electron microphotograph of a fine precipitate (Mo-based precipitate) effective for super-refining  $\gamma$  grains;

FIG. 3 is a graph showing a relation between an average grain size of prior austenite and a torsional fatigue strength with respect to Mo-added steel and Mo-free steel;

FIG. 4 is a graph showing a relation between an average grain size of prior austenite and a torsional fatigue strength with or without tempering;

FIG. 5 is a partial section view of a constant velocity joint; and

FIG. 6 is a section view showing a hardened texture layer in an inner wheel of a constant velocity joint.

#### DETD BEST MODE FOR CARRYING OUT THE INVENTION

The invention will be explained in detail below.

The components for machine structure according to the invention are a drive shaft for an automobile, an input shaft, an output shaft, a crankshaft, inner and outer wheels of a constant velocity joint, a hub, a gear and so on and have various forms and structures every the component. In any case, they have particularly a hardened layer subjected to a hardening in its portion requiring fatigue strengths or a whole thereof, and the hardened layer is important to have a hardness Hv of not less than 750 and an average grain size of prior austenite of not more than 7  $\mu\text{m}$  over a full thickness of the hardened layer.

The findings arriving at the above knowledge will be described below.

#### [Grain Size of Prior Austenite in Hardened Layer]

When the average grain size of the prior austenite in the hardened layer through the induction hardening exceeds 7  $\mu\text{m}$ , even if the hardness Hv of the hardened layer is increased to not less than 750 to improve the transgranular strength as mentioned later, the fatigue fracture is caused at a grain boundary of the prior austenite as a starting point. Therefore, grain size of the prior austenite in the hardened layer is required to be not more than 7  $\mu\text{m}$ , preferably not more than 6  $\mu\text{m}$ , more preferably not more than 5  $\mu\text{m}$ , further preferably not more than 3  $\mu\text{m}$ . Because, the intergranular strength becomes considerably strong

as the grain size is refined. In the conventional technique, even if the transgranular strength is increased, the intergranular strength is not increased and becomes a rate-determining step and hence it is not expected to further increase the strength. On the contrary, the intergranular strength is considerably increased by refining the grain size, so that it is expected to further increase the strength.

Now, the average grain size of the prior austenite in the induction hardened portion is measured as follows.

An outermost surface layer in the hardened layer after the induction hardening has a martensite structure of 100% as an area ratio. The region of 100% martensite structure continues to a certain thickness ranging from the surface of the hardened layer, but the surface area of the martensite structure violently decreases after that. In the invention, a region ranging from the surface of the induction hardened portion to a place that the surface area of the martensite structure decreases to 98% is the hardened layer, and an average depth from the surface is a thickness of the hardened layer.

As to the hardened layer, the average grain size of the prior austenite are measured at positions of  $1/5$ ,  $1/2$  and  $4/5$  of the whole of the thickness from the surface, and when the average grain size of the prior austenite is  $7\text{ }\mu\text{m}$  in any positions, it is defined that the average grain size of the prior austenite grains is not more than  $7\text{ }\mu\text{m}$  over the full thickness.

Moreover, the average grain size of the prior austenite grains is measured by corroding a section of the hardened layer with a corroding solution, which is formed by dissolving 50 g of picric acid in 500 g of water and adding 11 g of sodium dodecylbenzene sulfonate, 1 g of ferrous chloride and 1.5 g of oxalic acid, and observing the corroded section at 5 places every each position by means of an optical microscope of from 400 magnification (area of one place:  $0.25\text{ mm} \times 0.225\text{ mm}$ ) to 1000 magnification (area of one place:  $0.10\text{ mm} \times 0.09\text{ mm}$ ), and then analyzing with an image analysis equipment.

Incidentally, when the fatigue such as the rolling fatigue is dependent upon only the microstructure in the vicinity of an extremely surface layer, some effect is obtained even when the thickness of the hardened layer is about 1 mm, while in case of the torsional fatigue strength, it is preferable to make the thickness of the hardened layer to not less than 2 mm. It is more preferably not less than 2.5 mm, further preferably not less than 3 mm.

#### [Vickers Hardness of Hardened Layer]

When the Vickers hardness  $H_v$  of the hardened layer is less than 750, the transgranular strength of the hardened layer is weak, so that even if the prior austenite grains are refined, it can not be expected to improve the fatigue strength so as to match with such a refining. That is, even when the austenite grains are refined to increase the intergranular strength as mentioned above, if the transgranular strength is not increased, the transgranular fracture becomes rate-determined step and it can not be expected to increase the static strength and fatigue strengths. In the invention, therefore, the Vickers hardness  $H_v$  of the hardened layer (corresponding to the transgranular strength) is required to be not less than 750. Moreover, the upper limit of the Vickers hardness  $H_v$  of the hardened layer is not particularly limited, but it is preferable to be not more than 900 because when it exceeds 900, the amount of the elements added becomes large and hence the machinability of the base metal, the cold forgeability and the

resistance to quenching crack lower.

In the invention, the Vickers hardness is an average of values measured when 98 N (10 kgf) is struck to a position of 1/5 from the surface in the thickness of the hardened layer 5 times.

#### [Chemical Composition]

There will be described a chemical composition suitable for more increasing the transgranular strength of the hardened layer having the aforementioned particle size of prior austenite and Vickers hardness below.

C: 0.3-1.5 mass %

C is an element affecting a greatest influence on the induction hardenability, and contributes to the improvement of the fatigue strengths by increasing the transgranular strength of the hardened layer and more thickening the induction hardened portion. However, when the amount is less than 0.3 mass %, the hardened layer should be considerably increased for ensuring the required torsional fatigue strength, and hence the occurrence of quenching crack becomes remarkable and it is difficult to obtain a bainite structure as mentioned later. While, when it exceeds 1.5 mass %, it becomes inconvenient to ensure the machinability, cold forgeability and resistance to quenching crack. Therefore, the C amount is preferable to be 0.3-1.5 mass %.

Si: 0.05-3.0 mass %

Si increases the transgranular strength of the hardened layer and contributes to the improvement of the fatigue strengths. Further, it is an element useful for obtaining the bainite structure as mentioned later. From this meaning, it is preferable to be not less than 0.05 mass %. However, when it exceeds 3 mass %, it is difficult to ensure the machinability and cold forgeability because ferrite is solid-solution hardened, so that it is preferable to be not more than 3 mass %.

Mn: 0.2-2.0 mass %

Mn is an element for improving the induction hardenability and ensuring the thickness of the hardened layer. However, when the amount is less than 0.2 mass %, the effect is poor. Therefore, the Mn amount is preferable to be not less than 0.2 mass %, further preferably not less than 0.3 mass %. While, when it exceeds 2.0 mass %, the residual austenite increases after the hardening, which is easy to bring about the lowering of the hardness of the surface layer portion. Therefore, it is preferable to be not more than 2.0 mass %. Moreover, when the Mn amount is too large, the machinability tends to become disadvantageous, so that it is more preferably not more than 1.2 mass %, further preferably not more than 1.0 mass %.

Al: 0.005-0.25 mass %

Al is an element effective for the deoxidation of steel. Also, it is an element for suppressing the growth of austenite grains in the heating for the induction hardening to refine the induction hardened portion. When it exceeds 0.25 mass %, the effect is saturated and the increase of the cost is rather caused. Therefore, the Al amount is preferable to be not more than 0.25 mass %. Moreover, the above effect of Al is not developed when the



amount is less than 0.001 mass %, so that the amount is more preferably not less than 0.001 mass %. Further, it is preferable to be not less than 0.005 mass %.

Ti: 0.005-0.1 mass %

Ti has an effect that it bonds to N included as an inevitable impurity to form BN with B mentioned later to thereby prevent the fadeaway of the induction hardenability. Therefore, the amount is preferable to be not less than 0.005 mass %. While, when it exceeds 0.1 mass %, a great amount of TiN is formed and tends to lower the fatigue strengths as a starting point of fatigue fracture, so that the Ti amount is preferable to be 0.005-0.1 mass %. Further preferably, it is 0.01-0.07 mass %. Moreover, in order to effectively develop the hardenability of B by surely precipitating solid-soluted N as TiN, it is preferable that the Ti and N amounts are controlled to be  $\text{Ti (mass \%)/N (mass \%)} \geq 3.42$ .

Mo: 0.05-0.6 mass %

Mo has an action that austenite is refined by promoting the formation of bainite structure after the hot working in the heating for the induction hardening to refine the hardened layer. Also, it has an action that the growth of austenite grains in the heating for the induction hardening is suppressed to refine the hardened layer. Particularly, when the heating temperature in the induction hardening is 800-1000° C., preferably 800-950° C., the growth of austenite grains can be suppressed remarkably. Further, it is an element effective for the improvement of the hardenability, so that it is also used for the adjustment of the hardenability. In addition, it has an action of suppressing the formation of a carbide to prevent the lowering of the intergranular strength.

Thus, Mo is a very useful element for obtaining the effects of the invention, but when the amount is not less than 0.05 mass %, it is easy to render the average grain size of prior austenite in the hardened layer into not more than 7  $\mu\text{m}$ , so that it is preferable to be not less than 0.05 mass %. While, when the Mo amount exceeds 0.6 mass %, the hardness of the steel material in the hot working for shaping into a component form considerably increases to lower the workability. Therefore, the Mo amount is preferably 0.05-0.6 mass %, more preferably 0.1-0.6 mass %, further preferably 0.3-0.4 mass %.

Moreover, according to the inventors' examinations, the dragging effect through solid-solution atoms (Solute Drag Effect), pinning effect and the like are considered as a possibility on the refining effect of the prior austenite grains through Mo. Although it is not necessarily clear how to take these effects or the other effect, it is confirmed to develop at least the pinning effect. The details will be described later.

B: 0.0003-0.006 mass %

B is useful for refining the grain size of the prior austenite in the hardened layer when the microstructure prior to the induction hardening includes the bainite structure or martensite structure as mentioned later. Also, the addition of a slight amount improves the induction hardenability and thickens the hardened layer and hence has an effect of improving the fatigue strengths. Furthermore, it is preferentially segregated in the grain boundary to reduce P

concentration segregated in the grain boundary, and hence the intergranular strength is increased to improve the fatigue strengths. However, the effects are poor when the amount is less than 0.0003 mass %. While, when it exceeds 0.006 mass %, the effects are saturated and the increase of the cost is rather caused. Therefore, the B amount is preferably 0.0003-0.006 mass %, more preferably 0.0005-0.004 mass %, further preferably 0.0015-0.003 mass %.

S: not more than 0.1 mass %

S is an element forming MnS to improve the machinability of steel. When the amount exceeds 0.1 mass %, it is segregated in the grain boundary to lower the intergranular strength. Therefore, the S amount is preferably not more than 0.1 mass %, further preferably not more than 0.06 mass %.

P: not more than 0.10 mass %

P increases the transgranular strength of the hardened layer and contributes to the improvement of the fatigue strengths. However, when the amount exceeds 0.10 mass %, it is segregated in the grain boundary to lower the intergranular strength. Therefore, the P amount is preferable to be not more than 0.10 mass %.

The remainder other than the above elements may be Fe and inevitable impurities. However, it is particularly preferable to adjust the chemical composition so as to satisfy at least one of the following equations (1)-(3):

$C > 0.7 \text{ mass \%}$  (1)

$Si > 1.1 \text{ mass \%}$  (2)

$P > 0.02 \text{ mass \%}$  (3)

By satisfying either of the equations (1) to (3) can be made the Vickers hardness Hv of the hardened layer to not less than 750 to increase the transgranular strength, whereby the effect of improving the fatigue strengths accompanied with the refining of the average particle size of prior austenite to not more than 7  $\mu\text{m}$  can be developed considerably.

In the invention, the tempering treatment usually conducted after the induction hardening can be omitted. In this case, the temper softening is not caused, so that even if either of the equations (1) to (3) is not satisfied, Hv of not less than 750 can be satisfied in the above chemical composition range. In case of omitting the tempering, therefore, it is not necessarily required to satisfy at least one of the equations (1) to (3).

The inclusion of one or more selected from the following elements into the above chemical composition is effective to further improve the fatigue strengths.

Cr: not more than 2.5 mass %

Cr is effective for the improvement of the hardenability and is an element useful for ensuring the hardened depth, and may be added. However, when the amount is excessive, the carbide is stabilized to promote the formation of the residual carbide, which lowers the intergranular strength and deteriorates the fatigue strengths. Therefore, the Cr amount is desirable to be reduced as far as possible, but is allowed up to 2.5 mass %. Preferably, it is

not more than 1.5 mass %. Moreover, in order to develop the effect of improving the hardenability, it is preferable to be not less than 0.03 mass %.

Cu: not more than 1.0 mass %

Cu is effective for the improvement of the hardenability and also is solid-soluted in ferrite, in which the fatigue strengths are improved by such a solid solution strengthening. Furthermore, the formation of the carbide is suppressed to control the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, when the amount exceeds 1.0 mass %, cracks are caused in the hot working, so that the addition amount is not more than 1.0 mass %. More preferably, it is not more than 0.5 mass %. Moreover, the addition amount of less than 0.03 mass % is small in the effect of improving the hardenability and the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.03 mass %. Preferably, it is 0.1-1.0 mass %.

Ni: not more than 3.5 mass %

Ni is an element improving the hardenability and is used in case of adjusting the hardenability. Also, it is an element suppressing the formation of the carbide to suppress the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, Ni is a very expensive element, so that when it is added over 3.5 mass %, the cost of steel material increases, and hence the addition amount is not more than 3.5 mass %. Moreover, the addition amount of less than 0.05 mass % is small in the effect of improving the hardenability and the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.05 mass %. Preferably, it is 0.1-1.0 mass %.

Co: not more than 1.0 mass %

Co is an element suppressing the formation of the carbide to suppress the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, Co is a very expensive element, so that when it is added over 1.0 mass %, the cost of steel material increases, and hence the addition amount is not more than 1.0 mass %. Moreover, the addition amount of less than 0.01 mass % is small in the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.01 mass %. Preferably, it is 0.02-0.5 mass %.

Nb: not more than 0.1 mass %

Nb has an effect of improving the hardenability but also bonds to C, N in steel to act as a precipitation strengthening element. Also, it is an element improving the resistance to temper softening. The fatigue strengths are improved by these effects. However, when the amount exceeds 0.1 mass %, these effects are saturated, so that 0.1 mass % is an upper limit. Moreover, the addition amount of less than 0.005 mass % is small in the precipitation strengthening action and the effect of improving the resistance to temper softening, so that it is desirable to be not less than 0.005 mass %. Preferably, it is 0.01-0.05 mass %.

V: not more than 0.5 mass %

V bonds to C, N in steel to act as a precipitation strengthening element. Also, it is an element improving the resistance to temper softening. The fatigue strengths are improved by these effects. However, when the amount exceeds 0.5 mass %, the effects are saturated, so that it is not more than 0.5 mass %. Moreover, the addition amount of less than 0.01 mass % is small in the effect of improving the fatigue strengths, so that it is desirable to be not less than 0.01 mass %. Preferably, it is 0.03-0.3 mass %.

Ta: not more than 0.5 mass %

Ta may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.5 mass %, it does not contribute to the improvement of the strength, so that it is not more than 0.5 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.02 mass %.

Hf: not more than 0.5 mass %

Hf may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.5 mass %, it does not contribute to the improvement of the strength, so that it is not more than 0.5 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.02 mass %.

Sb: not more than 0.015 mass %

Sb may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.015 mass %, the toughness is deteriorated, so that it is not more than 0.015 mass %, preferably not more than 0.010 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.005 mass %.

Further, in order to improve the machinability of steel, it is preferable to include the following elements.

W: not more than 1.0 mass %

W is an element of improving the machinability through embrittlement action. However, when it is added over 1.0 mass %, the effect is saturated and the cost disadvantageously increases, so that it is preferable to be not more than 1.0 mass %. Moreover, W is preferable to be not less than 0.005 mass % for the improvement of the machinability.

Ca: not more than 0.005 mass %

Ca forms a sulfide with MnS, which acts as a chip breaker to improve the machinability, so that it may be added, if necessary. However, when the amount is added over 0.005 mass %, the effect is saturated and the cost increases, so that it is not more than 0.005 mass %. Moreover, when it is less than 0.0001 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.0001 mass %.

Mg: not more than 0.005 mass %

Mg is a deoxidation element but also has an effect of improving the machinability as a stress concentration source, so that it may be added, if necessary. However, when the addition is excessive, the effect is saturated and the cost increases, so that it is not more than 0.005 mass %. Moreover, when it is less than 0.0001 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.0001 mass %.

Ta: not more than 0.1 mass %

Se: not more than 0.1 mass %

Se and Te form MnSe and MnTe through bonding with Mn, respectively, which act as a chip breaker to improve the machinability. However, when the amount exceeds 0.1 mass %, the effect is saturated and the cost increases, so that each amount is not more than 0.1 mass %. Also, in order to improve the machinability, it is preferable that Se amount is not less than 0.003 mass % and Te amount is not less than 0.003 mass %, respectively.

Bi: not more than 0.5 mass %

Bi improves the machinability through the fusion, lubrication and embrittlement actions in the cutting, and may be added for this purpose. However, when it is added over 0.5 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.5 mass %. Moreover, when it is less than 0.01 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.01 mass %.

Pb: not more than 0.5 mass %

Pb improves the machinability through the fusion, lubrication and embrittlement actions in the cutting, and may be added for this purpose. However, when it is added over 0.5 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.5 mass %. Moreover, when it is less than 0.01 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.01 mass %.

Zr: not more than 0.01 mass %

Zr forms a sulfide with MnS, which acts as a chip breaker to improve the machinability. However, when it exceeds 0.01 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.01 mass %. Moreover, when it is less than 0.003 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.003 mass %.

REM: not more than 0.1 mass %

REM forms a sulfide with MnS, which acts as a chip breaker to improve the machinability. However, when it exceeds 0.1 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.1 mass %. Moreover, in order to improve the machinability, REM is preferable to be not less than 0.0001 mass %.

Although the above is described with respect to the preferable chemical composition range, the chemical composition is limited to the above range and further the steel texture prior to the induction hardening is made to the following texture, whereby there can be

obtained the aforementioned average particle size of the prior austenite of not more than 7  $\mu\text{m}$ .

That is, it is preferable that the microstructure of the base metal, i.e. microstructure prior to the hardening (corresponding to the microstructure other than that of the hardened layer after the induction hardening) has a bainite structure and/or a martensite structure and a total of either or both of the bainite structure and the martensite structure is not less than 10 volume %. Because, the bainite structure or the martensite structure is a microstructure finely dispersing the carbide therein as compared with a ferrite-pearlite microstructure, so that an area of an ferrite/carbide interface as a nuclear formation site of austenite in the heating and hardening increases to refine the resulting austenite, which effectively contributes to the refining of the grain size in the hardened layer after the hardening. Further, such a refining of the grain size in the hardened layer after the hardening increases the intergranular strength and improves the fatigue strengths.

Here, it is more preferable that the total of either or both of the bainite structure and the martensite structure is not less than 20 volume %.

Also, it is preferable that an upper limit of a microstructure fraction in the total of either or both of the bainite structure and the martensite structure is about 90 volume %. Because, when the microstructure fraction exceeds 90 volume %, the effect of refining the prior austenite grains in the hardened layer through the hardening is saturated but also the machinability is rapidly deteriorated.

Moreover, as to the refining of the grain size in the hardened layer after the hardening, the martensite structure has an effect approximately equal to that of the bainite structure. However, the bainite structure is advantageous as compared with the martensite structure because the amount of alloying elements added is less from an industrial viewpoint, and the machinability is good, and it is possible to produce at a low cooling rate.

Further, the volume fraction ratio of bainite and martensite is preferable to be generally bainite:martensite=100:0-40:60. As the microstructure prior to the hardening, the martensite structure is preferable for refining the grain size of the prior austenite in martensite of the hardened layer after the induction hardening. However, since martensite is hard, if a great amount of martensite is included in the base metal, the machinability lowers. Therefore, the volume fraction ratio of bainite and martensite is preferable to be bainite:martensite=100:0-40:60.

Next, the production method of the component for machine structure according to the invention will be explained.

The component for machine structure according to the invention can be produced by subjecting a steel material having the aforementioned chemical composition to a hot working such as bar steel rolling, hot forging or the like to shape into a component and then subjecting at least a part of the component to an induction hardening under a condition of heating temperature: 800-1000°C. In this case, the term "at least a part" means a portion requiring fatigue strengths.

There is the following method for rendering the average grain size of prior austenite in the induction hardened portion into not more than 7  $\mu\text{m}$ .

In the hot working, the total working ratio at 800-1000° C. is not less than 80% and the subsequent temperature region of 700-500° C. is cooled at a rate of not less than 0.2° C./s. Under these conditions, the microstructure prior to the hardening can be made to uniform and fine bainite and/or martensite structure (microstructure fraction: not less than 10 volume %). That is, since bainite and martensite are a microstructure finely dispersing the carbide therein as compared with a ferrite-pearlite microstructure, the area of ferrite/carbide interface as a nucleus formation site of austenite increases in the heating for the induction hardening, which is advantageous for refining the resulting austenite. For this end, it is required that the microstructure fraction in the total of either or both of bainite and martensite is not less than 10 volume %. Further, when the cooling rate in the temperature region of 700-500° C. is less than 0.2° C./s, the microstructure fraction in the total of either or both of bainite and martensite can not be made to not less than 10 volume %. More preferably, the cooling rate is not less than 0.5° C./s. Moreover, the volume ratio of bainite and martensite is preferable to be generally bainite:martensite=100:0-40:60 as previously mentioned.

Furthermore, the bainite and/or martensite structure prior to the induction hardening can be more refined by subjecting to a working of not less than 20% at a temperature region of lower than 800° C. Prior to the induction hardening (hereinafter referred to as a second working step), whereby the further refining of the prior austenite grains after the induction hardening can be attained, so that it is preferable to conduct the second working step. The working at the temperature region of lower than 800° C. may be carried out prior to the cooling at the above cooling rate (temperature region of 700-800° C.) in the hot working step, or a separate cold working may be conducted after the cooling or a warm working may be conducted by re-heating at a temperature of not higher than A.sub.1 transformation point. The working below 800° C. is preferable to be not less than 30%.

As the working method are mentioned, for example, cold forging, cold ironing, forming of rolling, shot peening and the like. By conducting the working below 800° C. is refined the bainite or martensite structure prior to the induction hardening, and hence the average grain size of the prior austenite in the hardened layer obtained after the induction hardening becomes finer to more improve the fatigue strengths.

The prior austenite grains having an average grain size of not more than 7  $\mu\text{m}$  are first obtained by combining the adjustment of the microstructure prior to the hardening by the above working and cooling with the following induction hardening conditions.

At first, when the heating temperature is lower than 800° C., the formation of austenite microstructure is insufficient and the hardened layer can not be obtained. On the other hand, when the heating temperature exceeds 1000° C. or when the temperature rising rate at 600-800° C. is less than 300° C./s, the growth of the austenite grains is promoted and at the same time the scattering of the grains becomes large to lower the fatigue strengths. That is, as to the grain size of the prior austenite in the finally obtained hardened layer, it is important how to prevent the grain growth at the austenite zone in the heating for the hardening. When the microstructure prior to the

hardening is a microstructure having fine bainite or martensite as mentioned above, there are many nucleus formation sites for inverse transformation to austenite, so that when the cooling is started while the produced austenite grains do not grow, the average particle size of the prior austenite in the hardened microstructure can be refined. The growth of the austenite grains proceeds as the temperature becomes higher or as the keeping time in the austenite zone becomes longer, in order to prevent the grain growth and finally obtain the prior austenite grains having an average grain size of not more than 7  $\mu\text{m}$ , the ultimate temperature in the heating is not higher than 1000° C. and the temperature rising rate at 600-800° C . is not less than 300° C./s.

Moreover, the ultimate temperature in the heating is preferable to be 800-950° C., and the temperature rising rate at 600-800° C. is preferably not less than 700° C./s, more preferably not less than 1000° C./s.

Also, as the residence time above 800° C. in the induction heating becomes long, the austenite grains grow and the grain size of the prior austenite tends to finally exceed over 7  $\mu\text{m}$ , so that the residence time above 800° C. is preferable to be not more than 5 seconds. More preferably, the heating time is not more than 3 seconds.

Moreover, the above effects develop more remarkably in steels containing Mo within the range defined in the invention. That is, FIG. 1 shows results examined on a relation between a heating temperature in an induction hardening and a grain size of prior austenite in a hardened layer with respect to Mo-added steel and Mo-free steel.

The results shown in FIG. 1 are obtained as follows.

That is, 150 kg of a steel material having a chemical composition shown in the following a-steel, b-steel, c-steel, d-steel and e-steel is melted in a vacuum melting furnace, hot-forged into 150 mm square to form a dummy billet, which is subjected to a hot working of 80% at 850° C. and cooled at 0.7° C./s within a temperature range of 700-500° C. to form a bar steel rolled material. Further, a part of the bar steels is subjected to a cold working of 20% after the cooling as a second working step.

(a-steel) C: 0.8 mass %, Si: 0.1 mass %, Mn: 0.78 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %, O: 0.0015 mass %, remainder: Fe and inevitable impurity

(b-steel) C: 0.53 mass %, Si: 0.1 mass %, Mn: 0.74 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, N: 0.0039 mass %, Mo: 0.37 mass %, Ti: 0.018 mass %, B: 0.0013 mass %, remainder: Fe and inevitable impurity

(c-steel) C: 0.9 mass %, Si: 0.1 mass %, Mn: 0.78 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %, O: 0.0015 mass %, remainder: Fe and inevitable impurity



remainder: Fe and inevitable impurity

(d-steel) C: 0.42 mass %, Si: 1.5 mass %, Mn: 0.78 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %, remainder: Fe and inevitable impurity

(e-steel) C: 0.42 mass %, Si: 0.2 mass %, Mn: 0.78 mass %, P: 0.05 mass %, S: 0.019 mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %, remainder: Fe and inevitable impurity

A test specimen for torsional fatigue is sampled from the resulting bar steel, subjected to an induction hardening at a frequency of 10-200 kHz and a heating temperature of 870-1050° C. and further subjected to a tempering in a heating furnace under conditions of 170° C.+30 minutes to obtain a test material. The induction hardening conditions are adjusted so that the temperature rising rate is not less than 300° C./s and the residence time above 800° C. is not more than 1 second.

The thus obtained test material is subjected to a torsional fatigue test to measure a stress broken at torsion number of 10.sup.5 on the torsional stepped test specimen of 18 mm $\phi$ . Also, the average grain size of prior austenite in the hardened layer through the induction hardening is measured by the previously mentioned method. Further, the Vickers hardness is measured at a position of 1/5 of the full thickness from the surface of the hardened layer. As the Vickers hardness is adopted an average value measured when 98 N (10 kgf) is struck 5 times.

As shown in FIG. 1, in any of the Mo-added steels and Mo-free steels, the grain size of prior austenite in the hardened layer can be made small by lowering the heating temperature in the induction hardening. Particularly, in case of the Mo-added steels, the refining of the grain size in the hardened layer is remarkably attained by rendering the ultimate temperature in the heating to not higher than 1000° C., preferably not higher than 950° C.

Although the reason on this phenomenon is not clear, the following can be presumed in relation to a carbonitride containing Mo and Ti. That is, it is considered that in case of the Mo-added steel, the above Mo-based fine carbonitride is precipitated to develop a strong pinning force, whereby the austenite grains are more refined as compared with the Mo-free steel. However, even in the induction hardening for a short time, it is considered that if the heating temperature largely exceeds over 1000° C., the fine (Mo, Ti).sub.2(C, N) is dissolved to lessen the pinning effect.

Moreover, it can be seen from FIG. 1 that in case of the Mo-added steel, the grain size of the prior austenite can be more refined by adding the second working step (cold working).

Further, the inventors have guessed that in the steels containing Mo, the reason why the average grain size of prior austenite in the hardened layer through the induction hardening can be more refined to improve the fatigue strengths is due to the fact that

the fine Mo-based precipitates are highly dispersed to make the above pinning effect large.

Now, the above a-steel is melted, rolled, subjected to forgings of 80% at 850° C. and 25% at 750° C. and then cooled in air (cooling rate in air: 0.8° C./s). Then, a sample for the observation with a transmission electron microscope is taken out from the starting material prior to the induction hardening to observe a state of fine precipitates. The sample for the observation with the transmission electron microscope is proved by taking out a flat plate sample from the central portion of the starting material and subjecting to an electrolytic polishing with a perchloric acid-methanol based electrolyte for thinning. As the observation zone is too thin, the frequency of dropping out the precipitated particles becomes high, while as the zone becomes too thick, it is difficult to recognize the precipitated particles, so that the thickness of the observation zone is adjusted to a range of 50-100 nm. Moreover, the thickness of the sample is estimated from an electron energy loss spectrum.

In FIG. 2 is shown an example of the actually obtained transmission electron microphotograph. Considering that the thickness of the sample in the view field is about 0.1  $\mu\text{m}$ , it is revealed that fine precipitates having a diameter of about 5-10 nm are dispersed in a high density of about 3000 particles per 1  $\mu\text{m}^2$ .

In the induction hardening, a nucleus of austenite is formed from a grain boundary of bainite or martensite, a packet boundary, a carbide and the like, which grows into grains. The above fine precipitates control the movement of the grain boundary face so as to push a finger (precipitates) into a balloon (grain boundary face) when the austenite grain boundary face arrives at the precipitates and passes therethrough. Such a control of moving the boundary face is called as a pinning. The pinning force is large as the precipitates becomes small when the amount of the precipitates is constant, or is strong as the amount of the precipitates becomes large when the size of the precipitates is constant.

In the induction heating according to the invention, it is guessed that the pinning is caused by the fine precipitates as shown in FIG. 2 to more promote the refining of the average grain size of prior austenite. Furthermore, it is confirmed that the fine precipitates shown in FIG. 2 are existent even in the material after the induction hardening below 1000° C., from which it is considered that the hardly solubility to the heat treatment at a high temperature for a short time effectively acts to the control of the grain growth of austenite in the induction hardening.

Then, the inventors conducted a model calculation by varying a precipitation volume ratio of Mo in order to estimate the influence of the precipitate dispersed state on the average grain size of prior austenite in the induction heating treatment. That is, assuming that the solid solution of Mo into the other precipitation phase is slight, if a precipitation volume ratio:  $f$  and average grain size:  $d$  of the Mo-based fine precipitates are determined, there is estimated the number of Mo-based fine precipitates per 1  $\mu\text{m}^2$  (precipitation density) in the case of uniform dispersion precipitation. If the average grain size of the prior austenite is governed by the pinning of the fine precipitation, such a size is inversely proportional to the precipitation density. So, there are examined the grain size and precipitation density developing the pinning effect considering that the grain size and density of the

precipitates in FIG. 2 attain the average grain size of prior austenite of 2  $\mu\text{m}$ . As a result, it has been found that the number of the precipitates per 1  $\mu\text{m}^3$ , which is directly effective for the control of the average grain size of the prior austenite, varies in accordance with the volume ratio of the precipitates, but when the volume ratio is, for example, about 0.2-0.4%, the sufficient pinning effect is developed and the preferable range capable of realizing the refining of the prior austenite grains is as follows.

That is, in order to attain the more refining of the prior austenite grains, it is preferable to ensure not less than 500 fine precipitated particles having a diameter of not more than 20 nm. Further, it is desirable to ensure not less than 1000 fine precipitates particles having a diameter of not more than 15 nm, more preferably not less than 2000 fine precipitated particles having a diameter of not more than 12 nm.

Then, as the residue after the precipitates are extracted from the base metal is identified by an X-ray diffractometry, it is guessed to be mainly hcp-type  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$ . Further, it has been revealed from results of EDX analysis attached with the transmission electron microscope that the atomic ratio of Mo to Ti is about 8:2 and Mo is a main component. Moreover, the precipitates include a composition deviated from a stoichiometric composition of complete  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$ . In any case, it is considered to be a composite carbonitride including Mo and Ti.

Now, the  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  precipitate is known to be relatively hard different from the precipitate of Cu or the like and considered to be high in the ability preventing the pass through the grain boundary face. Also, considering that Mo is fairly larger than Ti in the composition ratio and Mo is a hardly dispersing element, it is not thought that  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  becomes rapidly large even it is kept within a temperature range of about 600-700°C. as a  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  precipitation temperature for a short time. Therefore, in order to increase the precipitation amount of  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  to enhance the distribution density, the newly precipitation of  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  can be expected by isothermally keeping the above temperature range within a range of providing a microstructure fraction of bainite and martensite as mentioned later for a short time while suppressing the coarsening of the previously precipitated  $(\text{Mo}, \text{Ti})_{0.5}(\text{C}, \text{N})$  at minimum.

In FIG. 3 is shown a relation between a grain size of prior austenite and a torsional fatigue strength in the hardened layer. As seen from this figure, in the Mo-added steel, the grain size becomes small even in a region that the grain size of the prior austenite is not more than 7  $\mu\text{m}$  and also the fatigue properties are improved. On the contrary, in the Mo-free steel, as the grain size becomes not more than 7  $\mu\text{m}$ , even if the grain size is made further smaller than the above value, the fatigue strengths are not improved. This is considered due to the fact that since the hardness of the hardened layer in the Mo-free steel is lower than that of the Mo-added steel, when the grain size of the prior austenite is refined over a certain level, the fatigue fracture is a transgranular fracture and is not affected by the grain size of the prior austenite.

Furthermore, it has been seen that when any content of Si, P is increased in the Mo-added steel (c-steel, d-steel, e-steel), the effect of improving the torsional fatigue strength is large at a region that the grain size of the prior austenite is not more than  $7\text{ }\mu\text{m}$ . Therefore, as the Vickers hardness of the hardened layer is examined, it has been proved that the effect of improving the fatigue strengths by the refining of the prior austenite grains becomes very large when Hv of a-steel is 700, Hv of b-steel is 740, Hv of c-steel is 902, Hv of d-steel is 775, Hv of e-steel is 760 and the hardness Hv of the hardened layer is not less than 750.

Then, the inventors have discovered that an increment of the fatigue strengths by the refining of the grain size of the prior austenite can be made large by increasing the hardness of the above hardened layer and get an idea that the transgranular strength can be raised by omitting the tempering treatment after the induction hardening instead of the feature that the transgranular strength is raised by increasing any content of C, Si and P, and hence the fatigue strengths are raised by the omission of the tempering treatment.

Now, the torsional fatigue strength is examined on the above a-steel and b-steel provided that the tempering treatment is omitted in the step of preparing the specimen for the torsional fatigue test. The Vickers hardness Hv in the a-steel and b-steel omitting the tempering is 740 and 780, respectively.

In FIG. 4 is shown a relation between a grain size of prior austenite and torsional fatigue property in the hardened layer for the comparison between tempering and no tempering. From FIG. 4, it is seen that the fatigue strengths can be improved even by omitting the tempering.

Thus, the invention can positively adopt the method of conducting no tempering. In the usual high-strength steels, there is a case that cracks are caused in the component as the tempering is omitted. For this end, the tempering treatment after the induction hardening is a usual step. Such cracking is usually an intergranular fracture, which results from the lacking of the intergranular strength. In the invention, however, since the intergranular strength is high through the refining of the prior austenite grains, the cracking is hardly caused even in the omission of the tempering treatment. The omission of the tempering treatment is effective in the deterrence of softening due to the tempering and the reduction of the cost based on the tempering.

#### EXAMPLE 1

100 kg of a steel shown in Table 1 is melted and heated to  $1200^{\circ}\text{C}$ . and shaped into a sample for torsional fatigue test under hot working conditions and cold working conditions shown in Table 2. The shaped sample is first subjected to an induction hardening at  $1050^{\circ}\text{C}$ . and subsequently to an induction hardening under conditions shown in Table 2. Moreover, the induction hardening at  $1050^{\circ}\text{C}$ . is not carried out in Test No. 10. Also, in the tests other than Test Nos. 29 and 30, the tempering of  $160^{\circ}\text{C}.$ +1 h. is carried out after the induction hardening. The grain size of prior austenite and hardness in the induction hardened portion are measured in the same method as mentioned above. In the torsional fatigue test, stress broken at torsion number of  $10.\text{sup.}5$  is measured on the torsional stepped test specimen of  $18\text{ mm}\phi$ . Also, the microstructure prior to the induction hardening is observed by means of

an optical microscope to identify the microstructure, and at the same time the microstructure fraction (volume %) in one or total of bainite and martensite is measured.

The above measured results are also shown in Table 2. Nos. 7 and 25 are comparative examples wherein all contents of C, Si and P are low, and it is seen that the fatigue strengths in the invention examples are further improved as compared with these comparative examples. Also, when the content of Mo, B or Ti is insufficient as shown in Nos. 26, 27 and 28, the grain size of the prior austenite becomes coarse and the torsional fatigue strength lowers. In Nos. 26, 27 and 28, the microstructure of the base metal is particularly rendered into ferrite-pearlite, so that the grain size of the prior austenite is coarsened and the fatigue strengths lower. Furthermore, when the tempering treatment after the induction hardening is not conducted as shown in Nos. 29 and 30, the fatigue strengths are further improved as compared with steels of Nos. 1 and 7. In steel of No. 31, the total working ratio at 800-1000° C. in the hot working is small, so that the grain size of the prior austenite becomes large and the fatigue strengths are low.

TABLE 1

Symbol of steel	Chemical composition (mass %)								
	C	Si	Mn						
	P	Al	Mo	Ti					
	B	N	others						
A	0.75 0.0040	0.51	0.77	0.01	0.023	0.024	0.45	0.021	0.0023
B	1.21 0.0042	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
C	1.45 0.0022	0.50 0.0044	0.78	0.01	0.023	0.024	0.46	0.022	
D	0.42 0.0044	1.11	0.78	0.01	0.023	0.023	0.45	0.023	0.0022
E	0.41 0.0044	1.25	0.77	0.01	0.022	0.023	0.45	0.023	0.0023
F	0.42 0.0042	1.49	0.78	0.01	0.023	0.024	0.46	0.022	0.0021
G	0.48 0.0044	0.50	0.78	0.02	0.023	0.023	0.44	0.021	0.0021
H	0.42 0.0040	0.50	0.78	0.06	0.022	0.024	0.46	0.023	0.0022
I	0.41 0.0044	0.50	0.77	0.10	0.022	0.023	0.45	0.023	0.0022
J	0.75 0.0040	0.51	0.77	0.06	0.023	0.024	0.45	0.021	0.0023
K	0.41 0.0044	1.25	0.77	0.06	0.022	0.023	0.45	0.023	0.0023
L	0.70 0.0042	1.13	0.78	0.02	0.023	0.023	0.44	0.023	0.0021
M	0.70 0.0042	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
N	0.70 0.0021	0.50 0.0042	0.78	0.01	0.023	0.023	0.44	0.023	
O	0.70 0.0042	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
P	0.70 0.0021	0.50 0.0042	0.78	0.01	0.023	0.023	0.44	0.023	
Q	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021

		0.0042	Zr: 0.05						
R		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	Pb: 0.02						
S		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023
		0.0021	0.0042	Bi: 0.07					
T		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	Se: 0.01						
U		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	Te: 0.01						
V		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	Ca: 0.003						
W		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	REM: 0.002						
X		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0021
		0.0042	Cu: 0.3, Ni: 0.44, Te: 0.01						
Y		0.48	0.51	0.79	0.011	0.022	0.025	0.45	0.021 0.0024
		0.0041							
Z		0.70	0.50	0.78	0.01	0.023	0.023	0.03	0.023 0.0021
		0.0042							
AA		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023 0.0002
		0.0042							
AB		0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.002 0.0021
		0.0042							
AC		0.46	1.12	0.78	0.01	0.023	0.002	0.41	0.050 0.0022
		0.0044	Ca: 0.003						
AD		1.21	0.60	0.78	0.01	0.050	0.002	0.41	0.050 0.0022
		0.0044	Ca: 0.003						
AE		1.21	0.60	0.78	0.01	0.035	<0.001	0.41	0.050 0.0022
		0.0044	Ca: 0.003						

TABLE 2

Test No.	Hot working conditions					
	Total					
	Microstructure of non-working conditions					
	ratio		Cooling		Cold hardened portion	
	Residence		rate of		working	
	time		above		Fraction	
	Symbol		800° C.		condition	
	rising rate		500-700° C.		of bainite +	
	martensite		Temperature		Microstructure	
	of steel (%)		ratio		Heating	
	(%)	(° C./s)	(° C.)			
	800° C. (s) construction			(%)		
1	A	80	1.0	40	500	890
	1	pearlite + bainite		90		
2	B	80	1.0	40	500	880
	1	Proeutectoid carbide + bainite + pearlite		90		
3	C	80	1.0	30	500	880
	1	Proeutectoid carbide + bainite + pearlite		90		
4	D	80	1.0	20	500	880

	1		bainite + ferrite + pearlite	80			
5	E	80	1.0	5	500	885	
	1		bainite + ferrite + pearlite	80			
6	F	80	1.0	5	500	890	
	1		bainite + ferrite + pearlite	80			
7	G	80	1.0	15	500	875	
	1		bainite + ferrite + pearlite	80			
8	H	80	1.0	15	500	875	
	1		bainite + ferrite + pearlite	80			
9	I	80	1.0	25	500	890	
	1		bainite + ferrite + pearlite	80			
10	J	80	1.0	5	500	875	
	1		pearlite + bainite	90			
11	K	80	1.0	5	500	865	
	1		bainite + ferrite + pearlite	80			
12	L	80	1.0	25	500	875	
	1		pearlite + bainite	90			
13	M	80	1.0	5	500	880	
	1		pearlite + bainite	90			
14	N	80	1.0	10	500	875	
	2		pearlite + bainite	90			
15	O	80	1.0	0	500	875	
	1		pearlite + bainite	90			
16	P	80	1.0	40	500	880	
	1		pearlite + bainite	90			
17	Q	80	1.0	25	500	865	
	1		pearlite + bainite	90			
18	R	80	1.0	25	500	870	
	1		pearlite + bainite	90			
19	S	80	1.0	15	500	880	
	1		pearlite + bainite	90			
20	T	80	1.0	35	500	890	
	4		pearlite + bainite	90			
21	U	80	1.0	40	500	885	
	1		pearlite + bainite	90			
22	V	80	1.0	20	500	865	
	1		pearlite +	90			

23	W	80	bainite 1.0	15	500	875
	1		pearlite + bainite	90		
24	X	80	1.0	0	500	865
	1		pearlite + bainite	90		
25	Y	80	1.0	35	500	890
	1		pearlite + bainite	80		
26	Z	80	1.0	20	500	880
	1		ferrite + pearlite	0		
27	AA	80	1.0	35	500	890
	1		ferrite + pearlite	0		
28	AB	80	1.0	20	500	880
	1		ferrite + pearlite	0		
29	A	80	1.0	20	500	880
	1		pearlite + bainite	90		
30	G	80	1.0	15	500	875
	1		bainite + ferrite + pearlite	80		
31	A	50	1.0	10	500	890
	1		pearlite + bainite	90		
32	AC	80	0.5	0	300	950
	1		bainite + ferrite + pearlite	80		
33	AD	80	0.5	0	300	950
	1		Proeutectoid carbide + bainite + pearlite	80		
34	AE	80	0.5	0	300	950
	1		Proeutectoid carbide + bainite + pearlite	80		

Microstructure of Fatigue  
hardened portion property  
Average Torsional  
Grain Fatigue  
Vickers Size of Strength

Hardness Prior (+105)

$\gamma$  ( $\mu\text{m}$ ) (MPa) Remarks

3.4 941 Example  
2.4 959 Invention Example  
3.5 989 Invention Example

Test

No. (Hv)

1 823  
2 901  
3 917  
4 751



1.8	890	Invention Example	5	767
1.8	892	Invention Example	6	772
2.6	900	Invention Example	7	695
2.2	800	Comparative Example	8	750
2.1	840	Invention Example	9	763
2.7	869	Invention Example	10	833
3.4	922	Invention Example	11	783
2.8	910	Invention Example	12	764
2.7	976	Invention Example	13	768
2.7	925	Invention Example	14	764
3.2	933	Invention Example	15	764
1.8	930	Invention Example	16	767
3.2	943	Invention Example	17	761
1.6	936	Invention Example	18	759
3.1	935	Invention Example	19	754
1.7	936	Invention Example	20	754
3.8	934	Invention Example	21	756
3.1	920	Invention Example	22	752
2.7	929	Invention Example	23	750
2.3	930	Invention Example	24	770
1.9	935	Invention Example	25	694
2.0	805	Comparative Example	26	690
9.7	701	Comparative Example	27	673
8.7	729	Comparative Example	28	694
8.5	741	Comparative Example	29	820
3.4	990	Invention Example	30	752
2.2	890	Invention Example	31	823
8.1	780	Comparative Example	32	760
5.0	930	Invention Example	33	900
5.3	890	Invention Example	34	905
5.2	930	Invention Example		

## EXAMPLE 2

As a component for machine structure according to the invention is prepared a constant velocity joint 12 interposed for transmitting a motive energy from a drive shaft 10 to a wheel hub 11 as shown in FIG. 5.

The constant velocity joint 12 is a combination of an outer wheel 13 and an inner wheel 14. That is, the inner wheel 14 is swingably fixed to an inside of a mouth portion 13a of the outer wheel 13 through balls 15 fitted into a ball track groove formed in the inner face of the mouth portion 13a, while the drive shaft 10 is connected to the inner wheel 14. A stem portion 13b of the outer wheel 13 is, for example, spline-bonded to the hub 11, whereby the motive energy is transmitted from the drive shaft 10 to the hub 11 of the wheel.

A starting material of steel having a chemical composition shown in Table 3 is melted in a converter and continuously cast to form a cast bloom. The cast bloom has a size of 300+400 mm. The cast bloom is rolled into a billet of 150 mm square through a break down step and then rolled into a bar steel of 55 mm $\phi$ .

Then, the bar steel is cut into a given length and hot-forged to form an inner wheel of a constant velocity joint (outer diameter: 45 mm and inner diameter: 20 mm), and thereafter a groove for spline bond is formed on a fitting face thereof by machining or roll forming. Also, a rolling face for balls is formed by machining or cold forging. The cooling after the hot forging is carried out under conditions shown in Table 4. At this moment, the total working ratio in the hot forging and cold forging is obtained by adjusting an area reducing ratio of a section perpendicular to an axial direction of the rolling face.

As shown in FIG. 6, the rolling face 14a for balls lying to the outer wheel of the constant velocity joint is rendered into a hardened texture layer 16 by subjecting to an induction hardening at 1050° C. and to a subsequent induction hardening under conditions shown in Table 4 in an induction hardening apparatus with a frequency of 15 Hz, which is tempered under conditions of 180° C .+2 h in a heating furnace. Moreover, the tempering is omitted in a part of the constant velocity joints. The drive shaft is fitted onto the fitting face of the inner wheel of the thus obtained constant velocity joint, which is mounted to the mouth portion of the outer wheel of the constant velocity joint through balls (steel balls), while the hub is fitted into the stem portion of the outer wheel of the constant velocity joint, whereby there is obtained a constant velocity joint unit (see FIG. 5). Moreover, the specifications of the ball, outer wheel, drive shaft and hub are shown as follows.

Ball: hardened and tempered steel of high carbon  
chromium bearing steel SUJ2  
Outer Wheel: induction hardened and tempered steel of carbon  
steel for machine structure  
Hub: induction hardened and tempered steel of carbon  
steel for machine structure  
Drive Shaft: induction hardened and tempered steel of carbon  
steel for machine structure

Then, the durable test for rolling fatigue strength in the rolling face for balls is carried out in a motive energy transmission system of the constant velocity joint in which a rotational motion of the drive shaft is transmitted to the inner wheel of the constant velocity joint and then through the inner wheel to the hub.

The test for the rolling fatigue strength is carried out by the motive energy transmission under conditions that a torque is 900 N .multidot.m and an operating angle (an angle defined between axial line of inner wheel and axial line of drive shaft) is 20° and a revolution number is 300 rpm, and a time causing the peeling in the rolling face of the inner wheel of the constant velocity joint is evaluated as the rolling fatigue strength. Moreover, the dimensions and forms of the drive shaft, outer wheel of constant velocity joint and the like are set so that the inner wheel of the constant velocity joint becomes weakest in the durable test.

Also, the average grain size of prior austenite and hardness in the hardened layer with respect to the inner wheel of the constant velocity joints prepared under the same conditions are measured by the same methods as mentioned above.

In Table 4 are also shown these results.

TABLE 3

Symbol of	Chemical composition (mass %)								
	steel C	Si	Mn	P					
	S	Al	Mo	Ti	B				
	N	others							
A	0.75 0.0041	0.49	0.75	0.01	0.023	0.023	0.45	0.022	0.0021
B	1.23 0.0042	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0022
C	1.44 0.0021	0.50 0.0044	0.78	0.01	0.023	0.024	0.46	0.021	
D	0.41 0.0044	1.10	0.78	0.01	0.023	0.024	0.45	0.023	0.0022
E	0.42 0.0044	1.30	0.77	0.01	0.022	0.023	0.45	0.022	0.0023
F	0.42 0.0042	1.50	0.78	0.01	0.023	0.024	0.46	0.022	0.0021
G	0.48 0.0044	0.49	0.78	0.02	0.023	0.023	0.44	0.023	0.0023
H	0.41 0.0040	0.50	0.78	0.06	0.022	0.024	0.46	0.023	0.0022
I	0.42 0.0044	0.50	0.77	0.10	0.022	0.023	0.45	0.023	0.0022
J	0.75 0.0040	0.51	0.77	0.06	0.023	0.024	0.45	0.023	0.0021
K	0.41 0.0044	1.27	0.77	0.06	0.022	0.024	0.45	0.023	0.0023
L	0.70 0.0042	1.10	0.78	0.02	0.023	0.023	0.44	0.021	0.0021
M	0.70 0.0040	0.50	0.77	0.01	0.023	0.023	0.44	0.023	0.0021
N	0.70 0.0021	0.50 0.0042	0.78	0.01	0.023	0.023	0.44	0.021	
O	0.70 0.0042	0.50	0.77	0.01	0.023	0.023	0.44	0.023	0.0022
P	0.70 0.0021	0.50 0.0042	0.78	0.01	0.023	0.024	0.44	0.023	
Q	0.70 0.0042	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
R	0.70	0.50	0.79	0.01	0.023	0.023	0.44	0.023	0.0021

	0.0042	Pb: 0.02							
S	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	
	0.0022	0.0042	Bi: 0.07						
T	0.70	0.50	0.77	0.01	0.023	0.024	0.44	0.023	0.0021
	0.0042	Se: 0.01							
U	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0040	Te: 0.01							
V	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Ca: 0.003							
W	0.70	0.50	0.79	0.01	0.023	0.024	0.44	0.023	0.0021
	0.0042	REM: 0.002							
X	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Cu: 0.3, Ni: 0.44,							
		Te: 0.01							
Y	0.48	0.51	0.79	0.01	0.022	0.024	0.45	0.021	0.0024
	0.0041								
Z	0.70	0.50	0.78	0.01	0.023	0.023	0.02	0.022	0.0021
	0.0042								
AA	0.70	0.50	0.78	0.01	0.023	0.025	0.44	0.023	0.0002
	0.0042								
AB	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.002	0.0021
	0.0042								
AC	0.46	1.12	0.78	0.01	0.023	0.002	0.41	0.050	0.0022
	0.0044	Ca: 0.003							
AD	1.21	0.60	0.78	0.01	0.050	0.002	0.41	0.050	0.0022
	0.0044	Ca: 0.003							
AE	1.21	0.60	0.78	0.01	0.035	<0.001	0.41	0.050	0.0022
	0.0044	Ca: 0.003							

TABLE 4

Hot working conditions						
Microstructure of						
Total						
Microstructure of non-			hardened portion			
working			Cold		Induction hardening	
conditions			hardened portion			
Average			Fatigue			
Residence			Cooling		working	
property			ratio		Fraction	
Time			above		condition	
Presence or			rate of		of bainite +	
Symbol			Rolling		Temperature	
			800° C. 500-700° C.		Heating	
Working			rising rate		size of	
martensite			Vickers		Microstructure	
Test No.			prior $\gamma$		Fatigue	
of steel			absence of			
ratio (%)			(° C./s)			
800° C. (s)			(° C.)			
Hardness (Hv)			construction			
			(%)			
			life (hr)		Remarks	
			(μm)			
			tempering			
1	A	80	1.0	40	500	890
	1	Pearlite +		90	823	3.4
	presence	163	Invention	Example		
		bainite				
2	B	80	1.0	40	500	880
	1	Proeutectoid		90	901	2.4
	presence	177	Invention	Example		
		carbide + bainite +				

3	C	80	1.0	30	500	
	880	1		proeutectoid	90	917
	3.5	presence	173	Invention Example		
			carbide + bainite + pearlite			
4	D	80	1.0	20	500	885
	1		bainite +	80	751	1.8
	presence	151		Invention Example		
			ferrite + pearlite			
5	E	80	1.0	5	500	890
	1		bainite +	80	767	1.8
	presence	148		Invention Example		
			ferrite + pearlite			
6	F	80	1.0	5	500	875
	1		bainite +	80	772	2.6
	presence	155		Invention Example		
			ferrite + pearlite			
7	G	80	1.0	15	500	875
	1		bainite +	80	695	2.2
	presence	141		Comparative		
			ferrite +			
	Example					
			pearlite			
8	H	80	1.0	15	500	890
	1		bainite +	80	750	2.1
	presence	152		Invention Example		
			ferrite + pearlite			
9	I	80	1.0	25	500	875
	1		bainite +	80	763	2.7
	presence	152		Invention Example		
			ferrite + pearlite			
10	J	80	1.0	5	500	865
	1		pearlite +	90	833	3.4
	presence	167		Invention Example		
			bainite			
11	K	80	1.0	5	500	875
	1		bainite +	80	783	2.8
	presence	150		Invention Example		
			ferrite + pearlite			
12	L	80	1.0	25	500	880
	1		Pearlite +	90	764	2.7
	presence	181		Invention Example		
			bainite			
13	M	80	1.0	5	500	875
	1		Pearlite +	90	768	2.7
	presence	165		Invention Example		
			bainite			
14	N	80	1.0	10	500	
	875	2		pearlite +	90	764
	3.2	presence	164	Invention Example		
			bainite			
15	O	80	1.0	0	500	880
	1		pearlite +	90	764	1.8
	presence	166		Invention Example		
			bainite			

16	P	80	1.0	40	500	
	865	1		pearlite +	90	767
	3.2	presence	172	Invention Example		
			bainite			
17	Q	80	1.0	25	500	865
	1	pearlite +		90	761	1.6
	presence	168		Invention Example		
			bainite			
18	R	80	1.0	25	500	870
	1	pearlite +		90	759	3.1
	presence	161		Invention Example		
			bainite			
19	S	80	1.0	15	500	
	880	1		pearlite +	90	754
	1.7	presence	159	Invention Example		
			bainite			
20	T	80	1.0	35	500	890
	4	pearlite +		90	754	3.8
	presence	160		Invention Example		
			bainite			
21	U	80	1.0	40	500	885
	1	pearlite +		90	756	3.1
	presence	163		Invention Example		
			bainite			
22	V	80	1.0	20	500	865
	1	pearlite +		90	752	2.7
	presence	164		Invention Example		
			bainite			
23	W	80	1.0	15	500	875
	1	Pearlite +		90	750	2.3
	presence	162		Invention Example		
			bainite			
24	X	80	1.0	0	500	865
	1	pearlite +		90	770	1.9
	presence	160		Invention Example		
			bainite			
25	Y	80	1.0	35	500	890
	1	pearlite +		80	694	2.0
	presence	141		Comparative		
			bainite			
	Example					
26	Z	80	1.0	20	500	880
	1	ferrite +		0	690	9.7
	presence	120		Comparative		
			pearlite			
	Example					
27	AA	80	1.0	35	500	890
	1	Ferrite +		0	673	8.7
	presence	131		Comparative		
			pearlite			
	Example					
28	AB	80	1.0	20	500	880
	1	ferrite +		0	694	8.5
	presence	137		Comparative		
			pearlite			
	Example					
29	A	80	1.0	20	500	880
	1	pearlite +		90	820	3.4
	absence	180		Invention Example		
			bainite			
30	G	80	1.0	15	500	875
	1	Bainite + ferrite +		80	752	2.2

	absence	150	Invention Example			
			pearlite			
31	A	50	1.0	10	500	890
	1		pearlite +	90	823	8.1
	presence	140	Comparative			
			bainite			
	Example					
32	AC	70	0.7	0	300	950
	1		bainite + ferrite +	80	760	5.0
	presence	162	Invention Example			
			pearlite			
33	AD	70	0.7	0	300	950
	1		Proeutectoid	80	900	5.2
	presence	179	Invention Example			
			carbide + bainite +			
			pearlite			
34	AE	70	0.7	0	300	950
	1		Proeutectoid	80	906	5.2
	presence	173	Invention Example			
			carbide + bainite +			
			pearlite			

As seen from Table 4, Nos. 7 and 25 are comparative examples wherein all contents of C, Si and P are low, and the rolling fatigue life is improved in the invention examples as compared with these comparative examples. Also, when the content of Mo, B or Ti is lacking as in Nos. 26, 27 and 28, the grain size of the prior austenite is coarsened and the rolling fatigue life lowers. Further, in Nos. 26, 27 and 28, the microstructure of the base material is particularly ferrite-pearlite, so that the grain size of the prior austenite is coarsened and the rolling fatigue life lowers. In addition, when the tempering treatment is omitted after the induction hardening as in Nos. 29 and 30, the rolling fatigue life is further improved as compared with No. 1 steel and No. 7 steel, respectively. Moreover, in No. 31 steel, the total working ration of 800-1000° C. in the hot working is small, so that the grain size of the prior austenite becomes large and the rolling fatigue life is low.

CLM What is claimed is:

1. A component for machine structure characterized by comprising a hardened layer through an induction hardening in at least a part thereof, in which the hardened layer has a hardness Hv of not less than 750 and an average grain size of prior austenite grains is not more than 7  $\mu$ m over a full thickness of the hardened layer.

2. A component for machine structure according to claim 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si : 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3): C>0.7 mass % (1) Si>1.1 mass % (2) P>0.02 mass % (3)

3. A component for machine structure according to claim 2, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

4. A component for machine structure according to claim 2, wherein the chemical composition further contains one or more selected from

Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

5. A component for machine structure according to claim 2, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

6. A component for machine structure according to claim 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass % and the remainder being Fe and inevitable impurities in which the hardened layer is not subjected to a tempering.

7. A component for machine structure according to claim 6, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

8. A component for machine structure according to claim 6, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

9. A component for machine structure according to claim 6, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

10. A component for machine structure according to claim 2, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^3$  and an average particle size of the Mo-based precipitate is not more than 20 nm.

11. A method of producing a component for machine structure by subjecting at least a part of a starting material having a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3): C>0.7 mass % (1) Si>1.1 mass % (2) P>0.02 mass % (3) to an induction hardening at least once, wherein either or both of bainite structure and martensite structure in steel microstructure of the starting material prior to the induction hardening is adjusted to not less than 10 volume %, and an ultimate temperature of the induction hardening is not higher



than 1000° C.

12. A method of producing a component for machine structure according to claim 11, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

13. A method of producing a component for machine structure according to claim 11, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

14. A method of producing a component for machine structure according to claim 11, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

15. A material for induction hardening used for the formation of a component for machine structure having in at least a part of its surface a hardened layer with an average grain size of prior austenite of not more than 7  $\mu\text{m}$  through an induction hardening, characterized by having a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3): C>0.7 mass % (1) Si>1.1 mass % (2) P>0.02 mass % (3) and having a steel microstructure in which either or both of bainite structure and martensite structure is not less than 10 volume %.

16. A material for induction hardening according to claim 15, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

17. A material for induction hardening according to claim 15, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

18. A material for induction hardening according to claim 15, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

19. A material for induction hardening according to claim 15, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^2$  and an average particle size of the Mo-based precipitate is not more than 20 nm.

20. A component for machine structure according to claim 3, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

21. A component for machine structure according to claim 20, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

22. A component for machine structure according to claim 3, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

23. A component for machine structure according to claim 4, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

24. A component for machine structure according to claim 7, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

25. A component for machine structure according to claim 24, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

26. A component for machine structure according to claim 7, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

27. A component for machine structure according to claim 8, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and

REM: not more than 0.1 mass %.

28. A method of producing a component for machine structure according to claim 12, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

29. A method of producing a component for machine structure according to claim 28, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

30. A method of producing a component for machine structure according to claim 12, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

31. A method of producing a component for machine structure according to claim 13, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

32. A material for induction hardening according to claim 16, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

33. A material for induction hardening according to claim 32, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

34. A material for induction hardening according to claim 16, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

35. A material for induction hardening according to claim 17, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

36. A material for induction hardening according to claim 16, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^3$  and an average particle size of the Mo-based precipitate is not more than 20 nm.

37. A material for induction hardening according to claim 17, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^3$  and an average particle size of the Mo-based precipitate is not more than 20 nm.

38. A material for induction hardening according to claim 18, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1  $\mu\text{m}^3$  and an average particle size of the Mo-based precipitate is not more than 20 nm.

INCL INCLM: 420/084.000  
INCLS: 148/567.000; 420/121.000; 420/089.000  
NCL NCLM: 420/084.000  
NCLS: 148/567.000; 420/089.000; 420/121.000  
IC IPCI C22C0038-00 [I,A]; C21D0001-42 [I,A]; C22C0038-20 [I,A]  
CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> d 122 1-22 pi

L22 ANSWER 1 OF 30 USPATFULL on STN  
PI US 20080247900 A1 20081009

L22 ANSWER 2 OF 30 USPATFULL on STN  
PI US 20070193658 A1 20070823

L22 ANSWER 3 OF 30 USPATFULL on STN  
PI US 20070163687 A1 20070719

L22 ANSWER 4 OF 30 USPATFULL on STN  
PI US 7195736 B1 20070327  
WO 2001059170 20010816

L22 ANSWER 5 OF 30 USPATFULL on STN  
PI US 20070062619 A1 20070322

L22 ANSWER 6 OF 30 USPATFULL on STN  
PI US 20060285992 A1 20061221

L22 ANSWER 7 OF 30 USPATFULL on STN  
PI US 20060239853 A1 20061026

L22 ANSWER 8 OF 30 USPATFULL on STN  
PI US 20060157163 A1 20060720

L22 ANSWER 9 OF 30 USPATFULL on STN  
PI US 20050265886 A1 20051201

L22 ANSWER 10 OF 30 USPATFULL on STN  
PI US 20050252580 A1 20051117

L22 ANSWER 11 OF 30 USPATFULL on STN  
PI US 20050207687 A1 20050922

L22 ANSWER 12 OF 30 USPATFULL on STN  
PI US 20050161125 A1 20050728

L22 ANSWER 13 OF 30 USPATFULL on STN  
PI US 20050058567 A1 20050317  
US 7445680 B2 20081104

L22 ANSWER 14 OF 30 USPATFULL on STN  
PI US 20050025658 A1 20050203

L22 ANSWER 15 OF 30 USPATFULL on STN  
PI US 20050022906 A1 20050203

L22 ANSWER 16 OF 30 USPATFULL on STN  
PI US 20040129243 A1 20040708  
US 7472674 B2 20090106

L22 ANSWER 17 OF 30 USPATFULL on STN  
PI US 20040055667 A1 20040325  
US 6911268 B2 20050628

L22 ANSWER 18 OF 30 USPATFULL on STN  
PI US 20030178105 A1 20030925  
US 6764645 B2 20040720

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PI US 20030152476 A1 20030814

L22 ANSWER 20 OF 30 USPATFULL on STN  
PI US 20030138343 A1 20030724  
US 6797231 B2 20040928

L22 ANSWER 21 OF 30 USPATFULL on STN  
PI US 20030113223 A1 20030619  
US 6783728 B2 20040831

L22 ANSWER 22 OF 30 USPATFULL on STN  
PI US 20030084965 A1 20030508  
US 6838048 B2 20050104

=> s l22 or l14  
L23 69 L22 OR L14

=> duprem l23  
DUPREM IS NOT A RECOGNIZED COMMAND  
The previous command name entered was not recognized by the system.  
For a list of commands available to you in the current file, enter  
"HELP COMMANDS" at an arrow prompt (=>).

=> dup rem l23  
PROCESSING COMPLETED FOR L23  
L24 69 DUP REM L23 (0 DUPLICATES REMOVED)

=> d l24 1-69 pi

L24	ANSWER 1 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2009001887	A	20090108	JP 2007-165962	20070625

L24	ANSWER 2 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2009001864	A	20090108	JP 2007-163851	20070621
L24	ANSWER 3 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008308727	A	20081225	JP 2007-157349	20070614
L24	ANSWER 4 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008308704	A	20081225	JP 2007-154899	20070612
L24	ANSWER 5 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008149340	A	20080703	JP 2006-338791	20061215
L24	ANSWER 6 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2008013788	A	20080124	JP 2006-183512	20060703
L24	ANSWER 7 OF 69	USPATFULL	on STN		
PI	US 20080247900	A1	20081009		
L24	ANSWER 8 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	WO 2007007423	A1	20070118	WO 2005-JP22368	20051206
	W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW				
	RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG, BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM				
	JP 2007016278	A	20070125	JP 2005-198794	20050707
	JP 2007023351	A	20070201	JP 2005-208597	20050719
	JP 2007031755	A	20070208	JP 2005-214625	20050725
	CN 101218362	A	20080709	CN 2005-80050983	20080104
	KR 2008027913	A	20080328	KR 2008-702741	20080201
	IN 2008CN00647	A	20081128	IN 2008-CN647	20080207
L24	ANSWER 9 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2007031787	A	20070208	JP 2005-217453	20050727
L24	ANSWER 10 OF 69	USPATFULL	on STN		
PI	US 20070193658	A1	20070823		
L24	ANSWER 11 OF 69	USPATFULL	on STN		
PI	US 20070163687	A1	20070719		

L24 ANSWER 12 OF 69 USPATFULL on STN  
PI US 20070062619 A1 20070322

L24 ANSWER 13 OF 69 USPATFULL on STN  
PI US 7195736 B1 20070327  
WO 2001059170 20010816

L24	ANSWER 14 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2006348321	A	20061228	JP 2005-173112	20050614

L24	ANSWER 15 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2006299296	A	20061102	JP 2005-118366	20050415

L24	ANSWER 16 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2006249457	A	20060921	JP 2005-64316	20050308

L24	ANSWER 17 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2006206967	A	20060810	JP 2005-21019	20050128

L24	ANSWER 18 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2006037177	A	20060209	JP 2004-220223	20040728

L24 ANSWER 19 OF 69 USPATFULL on STN  
PI US 20060285992 A1 20061221

L24 ANSWER 20 OF 69 USPATFULL on STN  
PI US 20060239853 A1 20061026

L24 ANSWER 21 OF 69 USPATFULL on STN  
PI US 20060157163 A1 20060720

L24	ANSWER 22 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2005220423	A	20050818	JP 2004-30993	20040206

L24	ANSWER 23 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2005059096	A	20050310	JP 2004-199624	20040706

L24	ANSWER 24 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	FR 2868083	A1	20050930	FR 2004-3038	20040324
	FR 2868083	B1	20060721		
	AU 2005232002	A1	20051020	AU 2005-232002	20050321
	CA 2559562	A1	20051020	CA 2005-2559562	20050321
	WO 2005098070	A2	20051020	WO 2005-FR684	20050321
	WO 2005098070	A3	20061005		

W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,  
CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD,

GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
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 NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM,  
 SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW  
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 MR, NE, SN, TD, TG

EP 1727919 A2 20061206 EP 2005-742733 20050321  
 R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,  
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 HR, LV, MK, YU  
 CN 1950533 A 20070418 CN 2005-80014026 20050321  
 BR 2005008776 A 20070904 BR 2005-8776 20050321  
 JP 2007530780 T 20071101 JP 2007-504447 20050321  
 US 20070193658 A1 20070823 US 2006-593463 20060919  
 MX 2006010816 A 20061120 MX 2006-10816 20060921  
 IN 2006CN03491 A 20070615 IN 2006-CN3491 20060922  
 KR 2007021185 A 20070222 KR 2006-722040 20061024

L24 ANSWER 25 OF 69 USPATFULL on STN  
 PI US 20050265886 A1 20051201

L24 ANSWER 26 OF 69 USPATFULL on STN  
 PI US 20050252580 A1 20051117

L24 ANSWER 27 OF 69 USPATFULL on STN  
 PI US 20050207687 A1 20050922

L24 ANSWER 28 OF 69 USPATFULL on STN  
 PI US 20050161125 A1 20050728

L24 ANSWER 29 OF 69 USPATFULL on STN  
 PI US 20050058567 A1 20050317  
 US 7445680 B2 20081104

L24 ANSWER 30 OF 69 USPATFULL on STN  
 PI US 20050025658 A1 20050203

L24 ANSWER 31 OF 69 USPATFULL on STN  
 PI US 20050022906 A1 20050203

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PI	JP 2004292929	A	20041021	JP 2003-89959	20030328
	JP 3912308	B2	20070509		

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PI	JP 2004025205	A	20040129	JP 2002-182228	20020621
	JP 3789856	B2	20060628		

L24 ANSWER 34 OF 69 USPATFULL on STN  
 PI US 20040129243 A1 20040708  
 US 7472674 B2 20090106

L24 ANSWER 35 OF 69 USPATFULL on STN  
 PI US 20040055667 A1 20040325  
 US 6911268 B2 20050628



L24	ANSWER 36 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147482 JP 3851147	A B2	20030521 20061129	JP 2001-349100	20011114
L24	ANSWER 37 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147481 JP 3851146	A B2	20030521 20061129	JP 2001-349097	20011114
L24	ANSWER 38 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147479 JP 3901994	A B2	20030521 20070404	JP 2001-349095	20011114
L24	ANSWER 39 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147436 JP 3750737	A B2	20030521 20060301	JP 2001-349099	20011114
L24	ANSWER 40 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003147435 JP 3747365	A B2	20030521 20060222	JP 2001-349098	20011114
L24	ANSWER 41 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	JP 2003073735 JP 4213370	A B2	20030312 20090121	JP 2001-258353	20010828
L24	ANSWER 42 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	FR 2830261 JP 2003183770 JP 3468239 CN 1410581 CN 1180113 US 20030084965 US 6838048	A1 A B2 A C A1 B2	20030404 20030703 20031117 20030416 20041215 20030508 20050104	FR 2002-11966 JP 2002-112457  CN 2002-144079  US 2002-259744	20020927 20020415  20020930  20020930
L24	ANSWER 43 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
PI	EP 1335035 EP 1335035 R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK JP 2003226933 JP 3758581 TW 228149 CN 1436875 CN 1210432 US 20030152476	A1 B1  A B2 B A C A1	20030813 20050420  20030815 20060322 20050221 20030820 20050713 20030814	EP 2003-250686   JP 2002-26368  TW 2003-92102006 CN 2003-103453 US 2003-357419	20030203   20020204  20030129 20030130 20030204

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PI US 20030178105 A1 20030925  
US 6764645 B2 20040720

L24 ANSWER 45 OF 69 USPATFULL on STN  
PI US 20030152476 A1 20030814

L24 ANSWER 46 OF 69 USPATFULL on STN  
PI US 20030138343 A1 20030724  
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PI US 20030113223 A1 20030619  
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L24 ANSWER 48 OF 69 USPATFULL on STN  
PI US 20030084965 A1 20030508  
US 6838048 B2 20050104

L24 ANSWER 49 OF 69 USPATFULL on STN  
PI US 20030066577 A1 20030410  
US 6761853 B2 20040713

L24 ANSWER 50 OF 69 USPATFULL on STN  
PI US 6475305 B1 20021105

L24	ANSWER 51 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2001234279	A	20010828	JP 2000-44821	20000222

L24	ANSWER 52 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	JP 2001192765	A	20010717	JP 2000-193780	20000628
	JP 3253293	B2	20020204		
	EP 1167561	A2	20020102	EP 2000-125344	20001130
	R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO				

L24	ANSWER 53 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2001152278	A	20010605	JP 1999-331045	19991122

L24	ANSWER 54 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
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PI	JP 2001131684	A	20010515	JP 1999-314366	19991104

L24	ANSWER 55 OF 69	CAPLUS	COPYRIGHT 2009	ACS on STN	
	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
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PI	WO 2000044953	A1	20000803	WO 2000-JP369	20000125
	W: CA, CN, KR, US				
	RW: AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE				
	CA 2323952	A1	20000803	CA 2000-2323952	20000125
	EP 1069198	A1	20010117	EP 2000-900930	20000125
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	CN 1113973	C	20030709	CN 2000-800083	20000125

	JP 2000282172	A	20001010	JP 2000-18101	20000127
	JP 3680674	B2	20050810		
	JP 2001214241	A	20010807	JP 2000-204882	20000706
	JP 3680708	B2	20050810		
	US 6475305	B1	20021105	US 2000-669552	20000926
L24	ANSWER 56 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 2000273574	A	20001003	JP 1999-81629	19990325
L24	ANSWER 57 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 2000219936	A	20000808	JP 1999-23459	19990201
L24	ANSWER 58 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 2000026933 JP 3893756	A B2	20000125 20070314	JP 1998-192878	19980708
L24	ANSWER 59 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 11001743 JP 3489656	A B2	19990106 20040126	JP 1998-52103	19980304
L24	ANSWER 60 OF 69	USPATFULL	on STN		
PI	US 5972129		19991026		
L24	ANSWER 61 OF 69	USPATFULL	on STN		
PI	US 5922145		19990713		
L24	ANSWER 62 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 10152754 JP 3724142	A B2	19980609 20051207	JP 1997-249242	19970912
L24	ANSWER 63 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 09025541	A	19970128	JP 1995-175318	19950712
L24	ANSWER 64 OF 69	USPATFULL	on STN		
PI	US 5645794		19970708		
L24	ANSWER 65 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 07150293	A	19950613	JP 1993-296667	19931126
L24	ANSWER 66 OF 69 PATENT NO.	CAPLUS KIND	COPYRIGHT 2009 DATE	ACS on STN APPLICATION NO.	DATE
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PI	JP 06248341	A	19940906	JP 1993-33687	19930223
L24	ANSWER 67 OF 69	USPATFULL	on STN		
PI	US 5107711		19920428		
L24	ANSWER 68 OF 69	USPATFULL	on STN		

PI US 4991447 19910212

L24 ANSWER 69 OF 69 USPATFULL on STN  
PI US 4840073 19890620

=> d cost

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
CONNECT CHARGES	15.24	32.59
NETWORK CHARGES	0.77	2.31
SEARCH CHARGES	105.28	582.80
DISPLAY CHARGES	123.01	228.13
	-----	-----
FULL ESTIMATED COST	244.30	845.83

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)	SINCE FILE ENTRY	TOTAL SESSION
CA SUBSCRIBER PRICE	0.00	-0.82

IN FILE 'CAPLUS, USPATFULL, SCISEARCH' AT 19:58:51 ON 31 JAN 2009

=> logoff

ALL L# QUERIES AND ANSWER SETS ARE DELETED AT LOGOFF

LOGOFF? (Y)/N/HOLD:y

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
FULL ESTIMATED COST	244.30	845.83
DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)	SINCE FILE ENTRY	TOTAL SESSION
CA SUBSCRIBER PRICE	0.00	-0.82

STN INTERNATIONAL LOGOFF AT 19:59:05 ON 31 JAN 2009